

A STUDY OF MEMORY
FOR
CONNECTED TRAINS OF THOUGHT

E. N. HENDERSON

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A STUDY OF MEMORY

FOR

CONNECTED TRAINS OF THOUGHT

BY

E. N. HENDERSON

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE
DEGREE OF DOCTOR OF PHILOSOPHY IN THE FACULTY OF
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INTRODUCTORY. EDUCATION AND EXPERIMENTAL PSYCHOLOGY.

Any one who, working from the point of view of a student of education, ventures upon the territory of the experimental psychologist is forced to come to some conclusion, for better or for worse, as to whether experimental psychology has anything to give to the intelligent appreciation of education. A decision on this matter will rest largely upon point of view. One's general philosophy will go far toward determining whether one says that the teacher has no real use for the experimentalist or that education must be revolutionized by this comparatively new science. From the historical point of view, it is interesting to note that consistency should keep experimental psychology the willing bond-servant of the science of education. For, if we regard the attempt of Herbart to deal quantitatively with consciousness as furnishing the initial impulse toward the development of experimental study of mental phenomena, then it is plain that in its beginnings this science was created to further an analysis, the great aim of which was a theory of teaching. Herbart was primarily interested in education, and his psychological theories were probably influenced largely by the bias of his educational principles. The experimental psychology that gives us what it declares to be a purely academic analysis of consciousness — an analysis professedly useless to the teacher — such a science is, indeed, an ungrateful child. As a matter of fact, is it not likely that a science of education, if ever there is such a subject, must be based on a psychology that does not fall short of a study of acts of will in such a way as to further practical efficiency in dealing with children and men? May not our generation be justified in saying not only that knowledge is power, but that all significant knowledge must be a source of practical strength? And if we have so far not profoundly modified educational practice by reason of our psycho-

logical investigations, should we lose hope? The Baconian method realized signally feeble results in the hands of Bacon himself. After all, will not any verdict on the relation of experimental psychology to education have to wait a few more years on practical results? It is in the hope that we may be working toward such results, possibly building better than we know, or than those about us know, that the following study is submitted, claiming to be on the one hand in the interest of education, and on the other a venture in the field of experimental psychology.

As a matter of fact, it is only by addressing itself to peculiarly educational problems that experimental psychology is apt to gain any results of substantial educational importance. The teacher, reading over the dreary tables of data that record experimental results, finds, it is true, a little that is significant for his purposes. Possibly it would be unjust to say that this is so little that it does not repay the effort expended in its search. Certainly, where the investigations were conceived in the interest of education, we may expect and get something. The so-called 'child-study' movement has aimed to place teaching on a 'scientific' basis. As a rule, however, it has been scarcely scientific enough itself, and many of its results are insufficiently criticised. But it would be hard to measure the effect of the spirit and attitude of child study upon ways of thinking and methods of work of teachers, and upon the curriculum generally. However unscientific from the point of view of a laboratory science, it was, nevertheless, as a rule more accurate and conclusive than mere common sense, and though it may have worshipped idols, they probably replaced the fetishes of a more debased superstition. The teacher who endeavors to apply the theory of culture epochs will very likely work more intelligently than one who simply follows in blind routine the grind of centuries.

Child study may be said to have stood for the thesis that the school programme should conform to the needs of the child that is, rather than those of the adult that is to be. In fact, it is claimed that only in being true to the nature of the child can we properly prepare for adult life. But the emphasis is laid, not

so much on education as preparation for the future, as on education as interesting and satisfying for the present. Thus inspired, the new education has introduced a multitude of devices to enrich the work of the school-room, to provide motives for it, and to render it interesting. It has done this, confident that the essential preparation for life may be gained far more easily and effectively in this way than by the unenlivened discipline of the old-fashioned masters. It has assumed that the natural way of doing things is the effective way, and has busied itself in hunting the natural way — which was to be revealed by the study of child nature, of the genesis of mind. But the assumption remains as yet unverified. No one has proved that the new methods of education are better than the old in preparing for life or even in teaching the rudiments of learning. The new education has, indeed, striven to be practical, and it may with justice be granted that a persistent attempt to be a thing ought ordinarily to approximate nearer to it than haphazard work. But it can scarcely be affirmed that the old education neglected the practical. In that it aimed to store up in childhood treasures that were to be used much later, it was apt to be miserly and to collect riches that were never used. Worse! The thief of forgetfulness all too often stole away most of its accumulations. On the other hand, while the new education may not build palaces never to be occupied, it runs the risk of not getting beyond mere play-houses. May we not question whether the palace crumbled into ruins will not be as useful to the man as the toy structures of the child? Does it not remain to be proved that the games, the imitations, the natural occupations of the child furnish the most effective means of preparing him for the life that is to come? Is that education which is practical in preparing for immediate needs more practical in the long run than the one that thinks almost solely of the remote future?

I do not think that we can doubt that our modern schools are more interesting than their forerunners. The old-fashioned schoolmasters were not concerned very much in pleasing the child. But as yet we have no means of determining adequately the effectiveness of results in education. That our educational methods succeed, too often means that they gratify the preju-

dices of parents or excite the interest of pupils, rather than that they prepare adequately for the future. The judgment of time may often be counted on to eliminate the unfit in this business of training for life. But a school ought to be able to test its methods before they land it in bankruptcy. Nor should its success, like that of a dramatic company, depend on the ability to gratify the fancy. We need usable criteria for determining the success of school work. These criteria should be based on the needs of life rather than on the work of the school. Otherwise they merely test the child's success in certain work without reference to the real value of the work itself, and the real standing of the child in the race of life. Such tests would be able to anticipate the careers of our graduates more confidently than those now in vogue.

In this period of educational experimentation, of storm and stress in school circles, the need of scientifically determined methods of examination by which we can get something like an adequate test of the effect of our various school methods is especially desirable. From whom are these methods of testing to come if not from the educational psychologist? Certainly no one is in a better position to view various subjects and methods impartially. The specialist in any department is apt to have his eyes turned toward his course of study. He will examine to find whether his students have learned what was taught them. Doubtless this is a very important kind of test. But who is to determine what value this learning has for life? Some will say that there is no way of settling this question except by waiting for the practical test of living. Unquestionably this is in many cases true; possibly in all cases. Yet if it were uniformly so, who is to collect the facts by which the verdict of life is brought home to the teacher? For this is not so simple a matter as it may appear. Suppose we could show that most of our ablest men knew Greek. Would this show that their ability was due to their study of Greek, or that, as Professor Thorndike suggests, most people with considerable ability happen to have been taught Greek. To disentangle apparent from real evidence in these matters, to determine in how far a college examination in history is comparable to a life examination in the same

subject, or in the citizenship to which it is supposed to contribute; such tasks certainly require special training, ability to gather a special kind of evidence, and the entire time of a special body of workers. A hopeless task, you may think, but certainly the matter is of such importance as to make any gain that may result from substituting scientific methods for guess-work a gain worth while. To settle by adequate tests the relative efficiency of different methods of learning to read, to write, to compute, would mean immense advance. Indeed, the imagination can picture an age in which the random work of our schools will be as much surpassed as is the scientific method of antiquity by modern experimentation. In such an age no one will mistake even experienced judgment for proof, and the number of questions in regard to which men will plunge into controversy instead of resorting to investigation will have been materially reduced.

It would seem then a not insignificant division to say that educational psychology works at two problems. The first is that of the nature of mental growth, and the second concerns the effect of mental training. These problems are mutually interdependent. Yet from the educational point of view each is worthy of distinct treatment. For the one is concerned with processes, the other with results; the former starts on foot new methods, the latter investigates the effect of these methods. That has its eyes turned toward the child, this directs its gaze toward the man. Both can profitably employ, indeed both must, to be effective, employ some experimentation. Statistical investigation may or may not be experimental. Methods of testing are themselves to be determined and justified only by experiment, and they are the means of determining the results of still more extensive educational experiments. We are not without examples of this psychology of the effects of training. The study by Professors Thorndike and Woodworth, 'The Influence of Improvement of One Mental Function upon the Efficiency of Other Functions'¹ is an illustration. Such researches offer evidence that experimental psychology is not utterly disconnected with education, and encourage further study along similar lines.

¹ PSYCH. REV., 1901, Vol. VIII., Nos. 3, 4, 6.

PART I. EDUCATION AND THE EXPERIMENTAL STUDY OF MEMORY.

Any test of the result of school work is at bottom a test of memory. We may raise on our educational banners the rallying cry 'not information but culture, not knowledge but power,' but the culture and the power are none the less results of the activity of a function that may best be given the general name, memory. A habit, we must admit, is only a memory ground in so well that we can act effectively without conscious adjustment.

Wherein the information-giving type of education may fall short is, therefore, not in its attempt to give knowledge, but in its failure to select the kind of knowledge that can most effectively be stored in memory, and to see to it that this knowledge becomes part of the life of the individual. The reforming maxim that we should 'learn nothing by heart' owes whatever truth it contains to its implied criticism of the knowledge that is committed to memory in this way. The great problem of education is, after all, how most usefully to store the memory, how to create the habits of thought and action that will be most valuable in future life. Hence the examination, or test of what is committed to memory, is an indispensable part of school practice. No system can get along without it. Examinations mean standards: definite, positive work. To have no examinations means loose work and uncertainty about results. The character of the examination is the test of the aim and quality of the course of study. A purely academic examination is indicative of a purely academic course. The most practical examination is that which requires an application of the material committed to memory. This sort of examination is in many lines difficult, yet teachers are coming to feel that it is the only true method. It is not quite so easy to grade pupils by it as by answers involving information in the specific form in which that information was given, but, what is far more

important, the examination of this sort correlates far more closely with that given by life itself. As a matter of fact, it is not so easy to determine the grading of life as it is to range test papers according to percentages.

If it be admitted that the storing of memory is the object of education, and that the examination should exist to reveal the results of the training, any investigations of the manner in which memory operates and how best to test it are certainly important. Teachers have been working on these problems so long that a well-criticised and fairly effective school practice may be said to exist. Yet with all the reading of examination papers that goes on, there has been, so far as I know, no careful study of them as revelations of a psychological process. For one thing, conditions are so different with different pupils that the examination tests rather these various conditions than the fate in the normal mind of the material presented in a certain way. Teachers do indeed recognize in the examination a means not only of grading the pupils, but also of estimating their own work. But this estimate is made in a very uncritical way. The average of the marks of the class may, it is true, be taken as the measure of whether the teacher has gained her aim, but it indicates no definite relationship between conditions of presentation and retention. The experienced examiner knows in a general way what questions she may expect to have answered by the average student. But we may hope, I take it, far more from investigations conducted under controlled and known conditions than from mere general experience.

EDUCATIONAL BEARING OF CERTAIN EXPERIMENTAL WORK ON MEMORY.

It has already been suggested that here and there among the reports of psychological experimentation may be found material of interest to the teacher. This is possibly even more true of work on memory than of that in any other field. Some account of it may not be amiss in a paper of this sort. The material may be said to consist of two main kinds: (1) Data gathered from experiments with classes of school children; (2) results of laboratory experimentation that have an educational value.

1. *Data Gathered from Experiments with Classes of School Children.*¹

This material we may naturally suppose to be of especial interest to the teacher. The method of most of the experiments was that of reading or exhibiting at a uniform rate a series of numbers, letters, syllables, words or objects, and asking the children to write out the series in the original order. The number of units in the series was by some observers varied, and the results noted. Others contented themselves with a fixed number of units, but the nature of the units in the series was varied. All observers tested children of various ages, and some contrasted the abilities of girls and boys. The results may be divided into two classes: (1) Those indicating the growth of power to reproduce the series with increasing age; (2) Those indicating the kind of material easiest reproduced, and the methods of presenting the series that were most efficacious.

1. Comparing such of the data of different observers as are sufficiently similar to admit of this, we discover that they agree in finding that the older children reproduce the series better.²

¹ The researches the results of which have been considered in this review are: (1) 'The Growth of Memory in School Children,' T. L. Bolton, *Am. Journal of Psych.*, Vol. IV., pp. 362-380. (2) 'Memory, an Experimental Study,' E. A. Kirkpatrick, *PSYCH. REV.*, 1894, pp. 602-609. (3) 'Influence de l'âge sur la mémoire immédiate,' B. Bourdon, *Revue Phil.*, No. 38, pp. 148-167. (4) 'La mémoire des mots,' A. Binet et V. Henri, *L'Année Psych.*, Vol. I., pp. 1-23. Also 'La mémoire des phrases,' pp. 24-59. (5) 'Experiments on Memory Types,' C. J. Hawkins, *PSYCH. REV.*, Vol. IV., pp. 289-294. (6) 'Ex. Untersuchung. ü. d. Gedächtnissentwicklung b. Schulkindern, A. Netschajeff, *Ztsch. für Psych.*, Vol. XXIV., pp. 321-351. (7) Research with same title, Marx Lob-sien, *Ztsch. für Psych.*, Vol. XXVII., p. 34.

² The most evident comparison lies between the results of Bolton and Bourdon, both of whom read series of digits at a uniform rate to classes, and asked for written reproductions. Bolton's scores indicated amounts of forgetting, but they can be converted into scores of amount remembered, and in this form they appear in the following table. The scores indicate the average percentage of numbers in a series retained by children of a certain age.

AGE OF SUBJECTS.

Experi- menter.	Nos. of Digits.	8 Years.	9 Years.	10 Years.	11 Years.	12 Years.	13 Years.	14 Years.	15 Years.
Bolton,	6	43.7	54.5	57.6	67.6	68.7	72.3	76.5	74.7
Bourdon,	6	22	59	56	61	74	43	90	47
Bolton,	7	22	35.4	33.8	37.5	48.5	50.8	63.9	59.3
Bourdon,	7	0	13	28	5	37	33	43	40
Bolton,	8	0	0	0	16	26.3	29.5	34.5	33.8
Bourdon,	8	0	0	0	0	19	19	33	20

Bolton's subjects were evidently as a rule brighter than those of Bourdon. The latter's scores also show greater variability, and indeed a very ragged sort of progress. This is doubtless due to the fewness of his subjects. Bolton had 100 children of each age. But it is by no means sure that the increase of ability with age is due to growth in power to retain. As Professor Thorndike indicates,¹ it is probably the result of a complicated group of factors, including better attentiveness, greater power of comprehending instructions, etc. The rate of improvement from year to year cannot be determined with sufficient definiteness to be of any significance. Different observers report nothing that indicates clearly anything but variability in this rate. Bolton's experiments with series of 6 digits show improvement of about 75 per cent. from 8 to 14 years of age. Bourdon's show 400 per cent. improvement in the same time. Kirkpatrick, using series of 10 monosyllabic words, finds an improvement of about 34 per cent. for girls and 60 per cent. for boys from the primary grades to the high school. Lobsien, using series of 9 words of 1, 2 or 3 syllables each, finds between the ages of 9 and 14 an almost equal improvement for boys and nearly 80 per cent. for girls. Kirkpatrick, Bourdon and Netschajeff unite in finding the greatest improvement somewhere between the ages of 8 and 14, but Binet, using series of 5 to 7 monosyllables, finds almost no improvement between 7 and 13. This is all the more striking, inasmuch as he used series of the same length as those of Bourdon. With many of his series Bourdon reports the best reproductions from children of 14, the older subjects proving no better, if not actually worse. Netschajeff seems to corroborate this notion. It is possible that these older pupils were lackadaisical in the experiment. Kirkpatrick finds improvement between the high school and college, but the college students tested were doubtless on the average of higher ability than the younger subjects. In general I think we may say that the experiments show the most rapid improvement in power of reproduction of series before the age of 14. After that, if there is any advance, it is slight.

As regards the relation between girls and boys, we may

¹ 'Notes on Child Study,' p. 78.

conclude that younger girls do better than boys of the same age. Whether this advantage is overcome after adolescence, we cannot tell. The testimony of Lobsien and Netschajeff shows no such change in the superiority of the girls, while that of Kirkpatrick indicates a reversal of the earlier relationship.

2. Passing to the question of the relative ease of reproducing different classes of material, we find similar contradictions and variations. Netschajeff finds number series the hardest of eight types of series to reproduce. Lobsien finds them easier than any other of the same types except those made up of objects seen.¹ Kirkpatrick finds series of shown words in general easier to reproduce than series of spoken words. Hawkins reverses this relation.² Certain points of agreement come out prominently, however. A series of objects seen is invariably reported as remembered better than a series of words. In Kirkpatrick's experiment series of objects were best retained; words presented to the eye were next in the order of ease of reproduction. Three days after his original experiment, he asked for a second reproduction. The number of objects remembered was three times as great as that of the words in the visually presented series. It is not strange that we remember the objects that we see about us better than what we read. Yet Kirkpatrick's experiment must be granted to be striking, and not without its lesson. The difficulty in remembering abstract words, that both Netschajeff and Lobsien found, is to be expected, and when one sees Lobsien's lists, one wonders whether the children were philosophers enough to understand many of them.

¹ The nature of the series used by these experimenters is indicated by the following list. The order is that of ease in reproduction.

Netschajeff.	Lobsien.
1. Objects.	1. Objects.
2. Words indicating things seen.	2. Numbers.
3. Sounds.	3. Words indicating things seen.
4. Words indicating sounds.	4. Words indicating tastes.
5. Words indicating tastes.	5. Sounds.
6. Abstract words.	6. Words indicating sounds.
7. Words indicating feelings.	7. Words indicating feelings.
8. Numbers.	8. Abstract words.

² Kirkpatrick is probably nearer the general fact here, as his results are corroborated for adults (see p. 17).

It is also noticeable that younger children find series of more than eight quite difficult to manage, indicating either a feebler immediate memory, or, what is more likely, less power of intense concentration of attention than they come to possess later. Hawkins made the interesting observation that with younger pupils a series of fifteen words could better be reproduced if the words were shown successively, one every 2 seconds, than if they were all given at once, and the subject allowed 30 seconds to look them over. With older pupils this difference disappeared. One is tempted to think, however, that the explanation offered by Hawkins, *i. e.*, that the span of immediate memory grows greater, may not be the entire account of the matter. Probably improved methods of committing to memory causes the older students to waste less time in learning the series shown simultaneously.

Netschajeff found that in general those who from independent evidence were found to be of the visual type had better memories than those of the motor or acoustic types. He thinks, however, that the motor element entered into the efforts of most subjects to commit to memory words shown, so that those with good visual memories really enjoyed the advantage of motor memories reinforced by those of sight.

Several studies have been made on the power of children to reproduce sentences or stories.¹ The only conclusions of importance refer to the growth with age of ability to recount the matter dictated. Experiments made by Lay² indicate that with college students a passage containing abstract material is much more difficult to retain than a concrete one.

2. *Results of Laboratory Experimentation.*

When we pass to the material offered by researches in the experimental laboratories to the study of educational problems, we find that the contributions may be classified under the following heads: (1) Conditions favorable or unfavorable to committing to memory; (2) the nature of the memory image as compared with the original experience.

¹ Binet (see reference, p. 8); Shaw, 'A Test of Memory in School Children,' *Ped. Sem.*, 1896-97, pp. 60-78.

² Lay, 'Mental Imagery,' *PSYCH. REV.*, Monograph Supplement, No. 17.

1. The ordinary way of fixing a thing in mind is by repetition. Practice creates habits. But laboratory researches have established some interesting things about the effect of repetition and the method thereof. To the teacher it might be worth while to know these. Ebbinghaus,¹ probably the earliest systematic experimenter in these fields, committed to memory series of nonsense syllables by repeating them. The difficulty of learning was estimated by the number of repetitions required. The rate of forgetting was also tested. He found that after a series was learned further repetitions fixed it better in memory. There would seem, however, to be a limit to this effect. Bair, who investigated carefully the results of practice,² concludes that after a certain time a physiological limit is reached, beyond which further practice does not increase either speed or accuracy — although it keeps the power at its climax. It is interesting to note that the mere ability to go over a series accurately does not mark the attainment of the highest excellence of which memory is capable. Such a limit may be conceived to be either the greatest speed in repetition or the longest retention in memory. Moreover, it is likely that practice after the highest speed is attained will not be utterly useless in causing longer retention of the series. Again, we ought to notice that memorizing a series of nonsense syllables is very likely largely a matter of motor associations, and so approximates closely to learning a motor habit. May not the same thing be said of nearly all the exercises that come under the head of learning by heart? They are as mechanical as learning to walk. Spelling and multiplication are gymnastic exercises. It is of great importance to know when repetition has done its work and drill may stop. Further, Bryan and Harter,³ in their study on learning telegraphy, found that after the limit of improvement seemed to have been reached, and progress had for a long time ceased, certain operators enter upon a second stage of growth, and struggle toward a new 'physiological limit.' Here we have an illustration of a common phenomenon in the

¹ 'Ueber das Gedächtniss,' Leipzig, 1885.

² 'The Practice Curve,' *PSYCH. REV.*, Monograph Supplement, No. 19.

³ *PSYCH. REV.*, Vol. IV., p. 27, and Vol. VI., p. 345.

class room. Certain pupils seem to stop for awhile, development is 'arrested' as it were. But the experienced teacher knows that this is often not the end, and awaits patiently the renascence of capacity for growth. How best to fill in such an interval, or to initiate the new era? These are problems for the educational psychologist.

The effectiveness of learning depends not alone on mere number of repetitions, but also on the way in which these are distributed. It is a common opinion that little or no gain comes from practice after fatigue sets in. Whatever can be said of this,¹ both Ebbinghaus and Jost² agree that it is better to have the repetitions scattered over considerable time, rather than concentrated within a short period. Jost found that a series of twelve syllables was better learned if repeated ten times a day for three days than if repeated thirty times in one day. Ebbinghaus indicated that there are limits to the extent of scattering that is desirable. Here we have the problem involved in the division of time in the school program. Teachers know that they get better results by having frequent short drills than by lengthening the periods and increasing the intervals between them. They must be glad to find their general idea corroborated by the psychologist, but they have yet to learn by experimental evidence the distribution of time that will be most suitable in various cases.

In regard to the length of the series which can best be grappled with as a unit of work, the experimenters come a little nearer giving practical information. With nonsense syllables a single repetition was found by Ebbinghaus to suffice for the learning of seven syllables. As the number of syllables was increased, the number of repetitions required to learn the series increased, at first very rapidly, then more slowly. These longer series committed by a greater number of repetitions were, I conjecture, retained better than the shorter series learned more easily. Most school work where mechanical memory alone is involved does not require the serial learning of more new units than can be grappled in a single act of thought. Hence the

¹ See 'Mental Fatigue,' E. L. Thorndike, *PSYCH. REV.*, Nov., 1900.

² *Ztsch. f. Psych.*, 1897, pp. 436-472.

repetitions are to fix in memory rather than to enable a bare reproduction. Longer series enter in where the units are connected because they belong to a common topic, as in the case of sentences, of passages, etc. Miss Steffens¹ contributes some information in regard to the length of the unit that can be most effectively used in learning such material. She found that if, instead of learning certain stanzas of 'Childe Harold' verse by verse, as her subjects were inclined to do, each stanza was read repeatedly as a whole, fewer repetitions were necessary, and the time of memorizing was reduced. She also found the same to be true of longer series of nonsense syllables. Doubtless, the reason why we prefer to take the shorter section is because our progress is then more evident. On the other hand, most of us have suddenly realized that we knew passages of considerable length when we have made no effort to commit them piecemeal, but have read or heard them a number of times. We may well suppose that we waste much time in learning by short sections. But where a thing is to be learned by heart, doubtless the sections might also be too long. The psychologists here give us a valuable suggestion, but not a definite rule.

When we contrast the effect of repetition upon memory with that of vividness, we are at once confronted with the difficulty of generalizing in regard to the latter. The lack of any standard to which we can refer various kinds of vivid stimuli make such experiments as those of Miss Calkins² inadequate to the formulation of any general law. By associating numerals in pairs she ascertained that a number would recall one occurring with it several times better than one paired with it only once but printed in a striking color. Moreover, the number was less apt to call up a recent associate with which it had been paired but once, than a vivid or a frequent one. The teacher may conclude that undesirable but strong associations may be overcome by constantly repeating others. This, however, is one of the commonest methods in education, and Miss Calkins' experiments do not indicate any definite way of determining degrees of vividness in such a way that we can establish for any case

¹ *Ztsch. f. Psych.*, 1900, pp. 321-380.

² *PSYCH. REV.* Monograph Supplement, No. 2.

how much repetition will overcome a given vivid association. It may be that such a law is unattainable.

The effect of rhythm on the ease with which we can commit series of nonsense syllables was elaborately investigated by Müller and Schumann.¹ That rhythm makes memorizing easier is a commonplace truth, but the specific value of different classes of rhythm for this purpose had never been investigated. I do not see, however, that Müller and Schumann have given teachers any news that it is important for them to learn. The study of the relation between the motor adjustment and the memory of series is more significant educationally. Stricker's well-known experiment, of trying to think the sound 'bubble' with the mouth open, brings out clearly the extent to which motor elements enter into our acoustic memories. Cohn² investigated the effect of pronunciation on memorizing series. Certain series were shown to the learner, and also pronounced by him. Others were shown, but all articulation by the learner was inhibited. In still other cases the subject pronounced some other sound or counted as the letters were being read. Those who seemed to be of the visualizing type were not bothered much by not articulating the letters nor by counting. On the other hand, those who were of the acoustic-motor type were seriously hampered by the lack of acoustic-motor associations or by the presence of interfering ones. Smith,³ whose experiments antedate those of Cohn, found that with all his subjects counting increased the number of errors in committing to memory a shown series. He also found that the characters of the deaf and dumb alphabet could be learned easier if they were made by the hands as they were being observed.

The importance of the motor element in committing to memory is emphasized especially by Bair,⁴ who experimented on the effect of breaking the sensory-motor associations involved in a habit, as compared with breaking the order of the sensory impressions. His subjects learned to write with rapidity a series

¹ *Ztsch. f. Psych.*, Vol. VI., pp. 81-190 and pp. 257-339.

² *Ztsch. f. Psych.*, Vol. XV., pp. 161-183.

³ *Am. Journal of Psych.*, 1896, pp. 453-490.

⁴ *PSYCH. REV.*, Monograph Supplement, No. 19.

of letters on a typewriter. Then the keys were capped so as to change the arrangement of the letters thereon. This was found to retard more the writing of a learned series than the change of the order of the letters in the series without modifying the lettering of the keys. It follows, Bair concludes, that the association between a sense impression and the motor response to it is in the case of such habits the hardest association to break. This is probably due to the fact that a new association of the sort is hard to form. I have already noted that all learning by heart at school is nothing more than a gymnastic drill. As James indicates,¹ the association in such cases is from sensory stimulus to motor response, the feeling of which constitutes the stimulus for the next response. Frequently we find it hard to anticipate the next sensory element without going through the motions that precede it. In such cases the association between sensory elements is comparatively weak. There is, however, a sensory element here that such analysis neglects. In spelling *village* for example, the thought of the word as a whole, possibly also of the object, enters in to determine the series of letters reproduced. The letters *v-i-l-l-a* might as easily lead on to *i-n* as to *g-e*. What prevents this is the total idea in the mind. But while the process of spelling is going on the motor feelings constitute the cues by which the succession of letters is controlled. The general thought 'spelling village' plus the feeling that we have pronounced *a* suffices to stimulate the pronunciation of *g* before we have thought of it. The ordinary stock association is between thinking *a* and then pronouncing it. In this case the feeling of having pronounced *a* leads to the pronunciation of *g*. That this should happen is due to the general thought in the mind. At this point it may be worth while to suggest that the change in the order of the letters in Bair's experiment may have destroyed not so much the sensory associations between the letters as the sensory-motor association between the feeling of having struck one key and the motor impulse to strike the next. If this is the case, he simply compared the strength of two sensory-motor associations. At any rate, we may be fairly sure that sensory-

¹ 'Psych.,' Vol. I., p. 116.

motor associations play the most important part in all thoroughly learned series that we are taught in the schools, and we are also comparatively sure that it would be harder for us to pronounce the symbol *a* as we now do *w* than to learn to spell *saw* after we had spent some time in putting these letters into *was*.

In leaving the subject of the importance of the motor associations in committing to memory, I wish to emphasize the thought that in the learning of series they are especially effective. If one tries to recall the episodes of a story, he will find, I think, that the points come out much more clearly and effectively if he *tells them* instead of merely imagining them. Where thought works out into movement we find it easier to travel straight on toward our goal, whereas unexpressed imaginations do not lead on so decisively, but waver to and fro. There can be no doubt that expression is indispensable to learning most things in the school room, and that memories thus reinforced are far more effective than those of experiences in which the pupils have merely assumed passive attitudes. But while expression is probably from the educational point of view the most valuable aid to memory, it is well to note that material furnished to both eye and ear is better retained than that presented to either alone. This fact was established by Münsterberg and Bigham.¹ They also found that in general visually presented series were better remembered than aurally presented ones, a conclusion that was verified by Miss Calkins.

There remains to chronicle the experiments that have been performed testing the effect on learning and remembering of various sorts of distraction and the extent to which certain habits interfere with others. W. G. Smith² performed experiments similar to those of Cohn and T. L. Smith already reported, except that his purpose was not so much to segregate the effect of the muscular responses in memorizing, as to estimate the effects of various sorts of distraction. His results can scarcely be generalized to advantage, but it is interesting to note that he found the learning of twelve syllables to be interfered with less

¹ PSYCH. REV., 1894, pp. 34-38.

² *Mind* (New Series), Vol. IV., pp. 47-73.

by carrying on addition at the same time than by repeating the sound *la* to the beat of a metronome. The addition, though complicated, was so well drilled that it required less thought than the much simpler exercise. However, it must be noted that to keep time required sensory attention, and thus interfered with the sensory attention to the syllables. We can think about one thing and do another more easily than we can think about two things at once. This information will probably not surprise the experienced teacher.

In regard to the effect on our powers of recall of distracting conditions in the interval between memorizing and recall, Big-ham¹ has made some interesting contributions. He found that the memory was in general affected more by acoustical disturbances than by optical ones; also that if what was to be retained consisted of visual images, optical disturbances affected it more, but acoustical disturbances were found to be especially destructive to auditory memories. Teachers generally have commented on the disturbing effect of noises. Possibly a more valuable reflection that the study of distraction suggests concerns the extent to which different functions act independently. The conception of the mind as consisting of a great number of comparatively independent aptitudes rather than of a few general powers is a still further amplification of this thought, and experiments on the effect of a habit upon the power to learn one that is apparently antagonistic tend to justify the notion. Bergström² found that if a pack of cards were sorted with piles placed in certain positions, this interfered with the natural ease of sorting them into piles differently placed. Münsterberg,³ however, maintains that apparently contradictory habits do not destroy each other, but that each can subsist beside the other, and be called forth on occasion. At first it is hard to create the new habit, but once formed it is easy to shift back and forth from the one to the other. Bair corroborates this view of Münsterberg, both from experiments on the typewriter, and by repeating Bergström's experiments with a view toward finding

¹ PSYCH. REV., 1894, pp. 453-461.

² *Am. Journal of Psych.*, Vol. VI., p. 438.

³ 'Gedächtnisstudien. Beiträge zur experimentellen Psychologie,' Heft 4.

whether the initial interference due to the readjustment necessary in forming a new habit would persist after both habits might be said to be formed. He found that practice constantly reduced the interference of shifting.

2. On the subject of the quality of the memory image as related to the original experience, what seems to me the most suggestive contribution that laboratory psychology has to give is that our memories represent, as it were, a sort of generalized experience. They are modified in the direction of a standard value. Leuba¹ suggests such a transformation. Philippe² noted the loss of particular factors in the memory images of certain objects, as a statue of Venus, a bangle, a cigarette, etc. Bentley,³ experimenting with colors, discovered that the memory image was as a rule darker, but when the subject was in the light it seemed lighter. Warren and Shaw⁴ noticed that in selecting by memory a square of a certain size from a number of squares of different sizes a tendency to choose from near the center of the list was observable. Xilliez⁵ observed that in endeavoring to repeat a series of numbers just heard there was a tendency to make the intervals between their values smaller. These are typical of that regress toward a general washed-out image which plays so important a part in discussions of the general idea. The nature of the images we retain is, of course, a matter of first importance to the teacher. Experimental psychology, however, has not contributed anything more definite to increase the knowledge of teachers regarding the fate of the ideas they so sedulously implant in the minds of their pupils.

Summary of Results.

What then are the results of experimental researches on memory that may be applied to education? We have learned that children grow in power to reproduce series, and that this growth is most rapid before fourteen. This increased power is

¹ *Am. Journal of Psych.*, Vol. V., pp. 370-384.

² *Revue Philos.*, Vol. XVI., pp. 508-524; Vol. XVIII., pp. 481-493.

³ *Am. Journal of Psych.*, 1899, pp. 1-48.

⁴ *PSYCH. REV.*, Vol. II., pp. 239-244.

⁵ *L'Année Psych.*, Vol. II., pp. 193-200.

due to greater ability to memorize, which in turn is due either to increased power of concentration, to greater knowledge, or to greater natural retentiveness. We have learned that boys before adolescence, and probably for several years after, do worse at such reproductions than girls of the same age; and that later on they probably catch up. We have been told that children remember series of objects far better than series of words, and that words indicating abstractions are very poorly retained. We know that after a thing is learned by heart further effort may strengthen our grip on it, though we do not know any way to determine practically the point at which such effort ceases to avail. We know that a certain effort expended at intervals over considerable time is likely to produce better results than if it were continuous, but we do not know the limits of effective scattering, nor whether the principle applies to anything save to learning by heart. We have found that larger units can frequently be memorized as wholes with greater economy of time than if we learned them in sections, but we do not know the size of the unit most favorable, nor have we any rule that can be applied to different classes of material. Repetition we have found to fix associations better than a certain kind of vividness. The principle is, however, so indefinite as to have little practical value, save that it may encourage us to repeated efforts to eliminate by repetition undesirable associations. We can be sure that rhythm helps to memorize, that expression is of enormous assistance, that two senses working together fix a series of ideas better than one, that apparently contradictory habits can exist side by side, and that disturbing sounds are especially destructive to memories of what has been learned, although sight memories are particularly affected by ocular distractions. Doubtless this is not all that experimental research on memory has to yield to education. But it represents about all. What can be said of it?

In the first place most teachers will say that they knew all that before. So they did — in a general way. Nevertheless, it may be agreed that the facts gain clearness and emphasis by being shown by experimental methods, not to speak of the advantage of having opinions converted into certainties. Again,

the criticism will be made that the facts thus derived are proved for special cases, and that no general rule such as can be applied in teaching is to be drawn from them. This is doubtless a serious criticism. Moreover, even if general principles could be drawn from the experiments, they would have to be modified to apply to special educational questions. The art of teaching, it may be urged, is one of continuous adjustment to special situations. Not so much general psychological principles as special applications of these, such as experience alone can make, is what is desirable. Nor is this criticism to be dismissed as the protest of a mere rule-of-thumb artisan. What we need is experiment directed toward express educational problems. Such work, doubtless, will derive general principles rather than special rules, but they will be principles directly applicable to education, because derived from a consideration of the school environment. They doubtless will not attain such accuracy as that afforded by laboratory research. However, numbers and statistical methods will compensate for this. On the other hand, the teacher, fully conscious that each subject, each lesson, each pupil, constitutes an individual problem, ought not to forget the value of a broad generalization summing up experience in the large. Principles prevent experience from crystallizing into poverty-stricken methods that appeal to their users, not so much from their educational efficiency as because these people are accustomed to them. Therefore, let us have principles, not to supplement experience, but to enable us to master it.

Herein we discern the peculiar value that a study of what experimental psychology has done may have to school men. It has given us principles to guide further research. While it may not contribute in the most direct and manifest manner to educational practice, its methods and its results furnish the basis on which we must proceed. The experimentalist is at present engaged in clearing our farm. Some small patches he has cultivated, and reaped therefrom a scanty harvest, but for the most part his task has been to remove forests, underbrush and rocks, and to make possible the productive tasks. We must know his work in order not to duplicate both his failures and successes,

when we experiment on educational problems. His work has been as a rule minutely critical, but it has concerned very simple and abstract matters. We need researches that will reach into the concrete work of the school and test its results.

One striking contrast is noticeable between the material used in most of the experimental work on memory that has been reviewed and the kind of memory work done in the school room. The former is largely concerned with power to retain unconnected, often meaningless series, whereas the school very rarely asks for work depending on this power alone. The experiments, therefore, bear on the most mechanical tasks of the pupil. But a more important kind of experiment would concern itself with memory for connected thought. Even spelling is a rational process. The letters make a whole by the character of which they are to a great extent determined. What interests the teacher is not so much the absolute strength of the most wooden sort of memory, but the methods of association by which the memory is stocked most richly and effectively. To ascertain these, and also what becomes of the association groups with the lapse of time, may well furnish abundant opportunity for research.

As a matter of fact the physiological and psychological processes involved in the remembering of a connected train of thought are probably far different from what we have in the case of a mere mechanical habit. The link of the common theme greatly increases the number of units that can be retained. Binet and V. Henri¹ found that by the use of a mnemonic device the number of digits that can be recalled on a single reading may be raised from eight to thirty-six. They also noted² a far smaller amount of forgetting in phrases than in series containing the same number of disconnected words. I performed a rough experiment as follows. I took from a popular novel sentences of twenty words each; *e. g.*, "A sprinkle of blood, occasionally quite a dash of it, reddened the leaves and tufts of grass along his pathway." From similar sentences I selected phrases having four words each, and putting five of

¹ *Revue Philos.*, No. 37, pp. 114-119.

² *L'Année Psych.*, No. I., pp. 1-59.

these together made series of twenty words each; *e. g.*, "Into their selfish dreams — like an eagle dancing — something important for him — forethought, zeal, and preparation — his fiddle and bow." Again, taking several of the sentences I arranged the words in as many series of twenty words each, the combinations making no sense either as a whole or in phrases. I read these various series at a uniform rate and in a monotone, and then asked the listening students to write down the words they remembered in as near the original order as possible. Several readings of each series were given. One student invariably got the sentences perfectly in two readings, sometimes in one. The series of phrases took him always two and sometimes three readings, while the series of disconnected words took from four to six readings, to learn. The difference was equally manifest when we compare the reproductions after a single reading. The words in the sentences were recalled with from no omissions to at most five; those in the series of phrases with from five to ten omissions; while there was an average of eight omissions in the case of the disconnected words. A second student required from two to four readings in order to get the sentences, from three to five to get the phrases, and from six to eleven to get the series of disconnected words. A third student made on a single reading one slight error in reproducing the sentence, omitted seven words from the phrase series, and eight from the series of disconnected words. The latter series required of him three readings, while the other two were perfected on the second trial.

The results of this experiment are such as we might certainly expect, but the consideration of the difference in the mental conditions involved reveals the difference between school memorizing and that which we have reviewed. In recalling the sentence the idea of the meaning is dominant. In the one quoted the general picture of a bleeding man traversing a pathway suggests the cue, 'a sprinkle of blood,' and each succeeding thought,—*i. e.*, 'quite a dash of it,' 'leaves and tufts of grass,' etc., — helps to fill in the details of the same picture—a picture that persists while the sentence is being spoken. One subordinate thought does not replace another. All are in the

mind at the same time. All that their serial order means is that they are emphasized in succession. To keep the original order of the thought and the special arrangement of words involves the mere mechanism of association by serial contiguity. But it is much more involved in remembering the series of phrases, where the thought of one phrase does not fuse with that of the others. It would, however, be an error to suppose even here that there is no common mental state to which all the separate thoughts contribute. We feel in a vague unanalyzed way that we must recall the five phrases of four words each that we have just heard. This feeling guides and stimulates our recall, much as the picture of the bloody trail leads to repeating the sentence. The mental state is difficult to analyze. It involves a recall of the total condition under which the phrases were learned with sufficient accuracy to range them in order and to exclude phrases belonging to other series. This vague guiding consciousness becomes quite prominent when some time later we endeavor to recall such a series. But it is doubtless present and just as important in the guidance of an immediate reproduction. It may be characterized as the attention absorbing itself in the situation in which the series was learned. Such an attitude exists as preliminary to the recall of the sentences, but it is quickly replaced by a sense of the meaning they convey—a far more potent ‘open sesame’ to the details of the series.

When we pass to the series of twenty disconnected words, the attitude of attention is reinforced still less by inherent combining forces. The main force of serial association by contiguity is required to do most of the work. Each of the twenty meanings conveyed by the twenty words is gone with the uttering of the word that expresses it. It gets little attention either in learning or recall. It is quite otherwise with the meanings of the words in the sentence. Each shares all the emphasis that every other gets, because it is part of that other. Ebbinghaus has given the average memory span for nonsense syllables as seven. We may suppose that for disconnected words it is from eight to ten. But with connected words it ranges with average minds from twenty to forty, depending upon the diffi-

culty of the form of expression and the degree of unity in the thought.

✓ School work is concerned largely with meanings. Words sink into mere means of expression. The kind of experiment on memory that most directly concerns the teacher, therefore, will be that which deals with different sorts of associated material. To find out how well comparatively different classes of such material are retained, to investigate the efficiency of different ways of learning it, to compare the way in which the memories vary with the lapse of time, this comes nearer the living problems with which education has to deal. We want an experimental psychology of rhetoric and methods of teaching, as well as of the relation of school training to practical life. ✓

The following research deals with connected material. It does not profess to have attained any results of strikingly practical value. It may claim, however, to have worked in material such as constitutes an important part of school-room work, and to have done something to indicate the possibility of far more extensive and valuable researches regarding the products of school training.

PART II. THE SPECIAL RESEARCH.

The experiments, the results of which it is the special object of this paper to discuss, consist in having certain passages of connected matter learned in a given time, and reproduced after definite intervals. A careful comparison of the successive reproductions with each other and with the original is then made, with the object of finding out both the amount and the character of the material retained on each occasion. The investigations bear on the relation between power of learning readily and of retaining what is learned, the relative amount of forgetting after different intervals, and the relation between memory for ideas and memory for words. Moreover, since classes of different ages were tested, the results indicate something about the effect of age and training on the power to learn and to remember. In two cases adults were given the same tests as children, thus furnishing sharply contrasted conditions of age and training. Inasmuch as one class of students took part in several tests, a comparison of their relative rank in each gives some notion of the influence of the kind of material upon the relative ability to learn and remember. Finally, a careful study of what ideas are reproduced on the first occasion and their fate as evidenced in the later reproductions sheds some light on the qualitative modifications of our ideas regarding certain things that occur with the lapse of time. The tests, it will be seen, consist of material like that which students of different subjects might be expected to learn and to reproduce in some fashion in the various exercises of the school room. They have therefore a direct bearing on the significance of the results of examinations, and on the fate of the ideas implanted by the teacher in the minds of the pupils.

THE METHOD.

The members of the class to be tested were informed that they were about to be asked to commit to memory as much of

a certain passage as they could in three minutes. They were told that this was ample time in which to go over the passage a number of times and to memorize a large part of it. The object of this statement was to allay the excitement that the thought of so short an interval might arouse, while insuring the putting forth of all the energies in as concentrated an effort as the individual could evoke. I do not think that many of the persons who took part felt their efficiency materially interfered with by the confusion of nervous excitement. As soon as these general instructions were given, a typewritten copy of the passage to be studied was handed to each member of the class, to be kept face downward until a signal was given. They were told that they should read the passage over at least twice, and then memorize it in any way they wished. This instruction aimed at insuring some attention to the ideas of the latter part of the passage. The class was also informed that a written reproduction of the passage would be called for, in which the words should be given where remembered. In case they were forgotten, the ideas that were retained were to be expressed as the subject chose. At a given signal the papers were turned, and the work began. It was stopped by having the subjects turn over the papers at the end of the three minutes.

Two days later I returned and asked for a second reproduction of the passage, giving instructions as before. In many cases I asked that the words which they were confident had occurred in the original passage be underscored. Four weeks later I returned again, and asked for a third reproduction, giving similar instructions. With the graduate students in Columbia University, who memorized on separate occasions three different passages, it was necessary to announce in the beginning that other reproductions would be expected. They found no difficulty, however, in carrying out my request to banish the thought of the passage from their minds during the interval. A similar warning was given to the mature students in the summer session of 1902 at Columbia University who took part in the experiment. Thus a comparison of notes was avoided. To the other classes nothing was said, and my second and third appearances were surprises. I assumed that the later reproductions would

be influenced far less by whatever discussion might appear spontaneously than by the effect of suggestion in keeping the passage before their thoughts, in case I warned them not to talk about it, assigning the reason that I expected them to write it out again. Moreover, with the younger classes a request that they do not communicate with each other would doubtless have stimulated rather than repressed such discussion. From a comparison of papers I am certain that there was very little gained by intervening conversations. I took the testimony of the subjects regarding the matter. Most declared that they had not talked about the passage at all. A few had discussed it, but an examination of their later papers showed little or nothing new. Their talks, therefore, could have had no effect except to strengthen their earlier impressions.

THE TESTS.

Five passages were used in the various experiments. They were as follows.

Test 1. — THE KING WHO BECAME JUST.

“ There was-once, | in the eastern-part-of Egypt,-a king, || whose-reign-had long been-a course-of savage-tyranny ; | long-had he ruined-the rich | and distressed-the poor. || Suddenly-he changed-his course | and ruled-so well as-to be called-the just. || When asked-by a favorite-the reason-for this-change, | he replied: || ‘ I saw-a dog, | which, soon after-it had bitten-off-the leg-of a fox, || was struck-on the head-by a great-stone, | that cracked-its skull. | The stone-was thrown-by a man, || who-at that instant-ran-in the way-of a horse | and was trod on-and lamed-forever. || A short time-after | the horse-broke-its ankle-bone-between two-stones. ||⁷ These-sudden-misfortunes-convinced me | that men-are used-as they use-others.’ ”

This passage was selected and adapted as one suitable for younger classes. It presents interesting and intelligible material, and contains a variety of elements. It is so condensed as to furnish abundant matter for a three-minute exercise in memorizing. The marks indicate the analysis on the basis of which the scoring of the number of ideas retained was based. The hyphens separate the detailed thoughts, the score in regard to

which was usually taken as the record of the excellence of the memory. The perpendicular lines separate certain subtopics, the score in regard to which I have compared with the score in detailed ideas. Finally, the parallel perpendiculars separate the main topics into which the thought of the passage was analyzed.

Test 2. — CICERO.

“Cicero, | the greatest-of the Roman-orators, || was born-at Arpinum, | an obscure-country-town. || His family-was of the middle class-only, | and without wealth, || yet he rose-rapidly | through the ranks-of Roman-official service | until at the age-of forty-six | he became-consul. ||⁵ In oratory-he is | by universal consent | placed side by side-with Demosthenes, | or at least-close after him. || He surpassed-the great-Attic-orator | in brilliancy-and variety, | but lacked-his moral-earnestness-and consequent-impressiveness. || He could be-humorous,-sarcastic, | pathetic,-ironical,-satirical, || and when he was-malignant | his mouth was-most-foul | and his bite-most-venomous. || His delivery-was impassioned-and fiery, | his voice strong,-full,-and sweet, | his figure-tall,-graceful,-and impressive.”

It was thought that this passage would be suitable for history or Latin classes of the high-school grade, and it was used with such subjects. It bore on work that frequently they were doing, and it offered a chance to study the influence of this work, besides appealing to the teachers as embodying material worthy of reflection.

These two passages were the ones used with by far the greater number of subjects. The other three: one, a condensed historical sketch; the second, a detailed description, and the last, an abstract discussion, were given to the same students. They represent widely different fields of thought, and may be taken as affording a good basis for comparing the memory for different classes of material. The passages follow.

Test 3. — THE HISTORY OF THE JEWS. (From Milman's ‘History of the Jews.’)

“The Jews,-without reference to-their religious-belief,-| are among-the most-remarkable-people-| in the annals-of man-

kind. || Sprung-from one-stock, | they pass-the infancy-of
 their nation | in a state of servitude-in a foreign-country, ||
 where, nevertheless,-they increase-so rapidly-as to become-on a
 sudden | the fierce-and irresistible-conquerors | of their native-
 valleys-in Palestine. || There they-settle down | under a form
 of government-and code of laws | totally unlike-those of any
 other | rude or-civilized-community. ||⁵ They sustain-a long-
 and doubtful-conflict, |⁵ sometimes-enslaved,-sometimes-victori-
 ous, | with the neighboring-tribes. || At length,-united-under
 one-monarchy, | they gradually-rise-to the rank | of a powerful,-
 opulent,-and commercial people. ||⁷ Subsequently,-weakened
 by-internal-discord, | they are overwhelmed-by the vast-mon-
 archies | which arose-on the banks-of the Euphrates, |⁷ and are
 transplanted-into a foreign-region. || They are partially-re-
 stored | by the generosity-or policy-of the Eastern-sovereigns, |
 to their native-land."

Test 4.—THE DUTCH HOMESTEAD. (From Irving's 'Legend of Sleepy Hollow.')

"It was-one-of those spacious-farm-houses, | with high-
 ridged-but lowly-sloping-roofs, | built-in the style-handed down
 from-the first-Dutch-settlers, || the low-projecting-eaves-forming
 a piazza-along the front | capable-of being closed up-in bad
 weather. || Under this-were hung-flails,-harness, | various-
 utensils-of husbandry, | and nets-for fishing-in the neighboring-
 river. || Benches-were built-along the side-for summer use;
 | and a great-spinning wheel-at one end, | and a churn-at the
 other, | showed-the various uses-to which this important-porch;
 might be devoted. || From this piazza-one might enter-the
 hall, | which formed-the center-of the mansion | and the usual-
 place of residence. || Here-rows-of resplendent-pewter |
 ranged-on a long-dresser | dazzled-his eyes. || In one corner-
 stood a huge-bag of wool, | ready-to be spun; | in another-a
 quantity-of linsy-woolsey, | just-from the loom; || ears-of Indian
 corn | and strings-of dried-apples-and peaches | hung-in gay-
 festoons-along the walls, | mingled-with the gaud-of red-pep-
 pers."

Test 5.—THE STAGES IN THE DEVELOPMENT OF HUMAN THEORY. (From Martineau's 'Comte's Positive Philosophy.')

“From the study-of the development-of human-intelligence, | in all-directions,-and through all-times, | the discovery-arises- of a great-fundamental-law, || to which-it is necessarily-subject, | and which-has a solid-foundation-of proof, | both-in the facts-of our-organization | and in our-historical-experience. || The law- is this :- | that each-of our-leading-conceptions,- | each-branch-of our-knowledge,- | passes-successively-through three-different- theoretical-conditions: || the Theological,-or fictitious; | the Metaphysical,-or abstract; | and the Scientific,-or positive. || In other words,-the human-mind,-by its nature, | employs-in its progress-three-methods-of philosophizing, | the character of which-is essentially-different, | and even-radically-opposed: | viz.,-the theological-method,-the metaphysical,-and the posi- tive. | Hence-arise-three-philosophies, | or general-systems-of conceptions-on the aggregate-of phenomena, | each of which- excludes-the others. || The first-is the necessary-point of de- parture-of the human-understanding; | and the third-is its fixed- and definitive-state. | The second-is merely-a state of transi- tion.”

THE CLASSES OF SUBJECTS TESTED.

The following classes of students took part in the experi- ments:

1. One hundred and three pupils in Public School No. 40, New York City. These were all boys varying in age from 10 to 16. The school includes both primary and grammar depart- ments, and all pupils are ranged from beginning to finishing classes in 16 grades; grade 1A being the lowest and 8B the highest. The pupils taking part in the experiment were in three grades as follows: 33 in grade 7B, 43 in grade 6B, and 27 in grade 5B.

2. Fifty-three pupils in the Erasmus Hall High School, Brooklyn. Of these 37 were girls and 16 boys. The school is arranged in 8 grades, beginning with grade 1, and the grades are divided into sections indicated by the letters A, B, etc. The pupils tested were in three grades: 23 in grade 1, section A, 18 in grade 4, section B, and 12 in grade 8, section B.

3. Twenty-one students in a course in psychology in Colum-

bia University. Most of them were seniors in Columbia College. Four, however, were women from Barnard College.

4. Eighteen graduate students in Columbia University.

5. Seventeen students in the summer session of 1902, at Columbia University. Of these 4 were women.

The following abbreviations will be used to indicate the different classes of subjects: P. S. 7B, P. S. 6B, and P. S. 5B will signify the different grades in Public School No. 40. E. H. S. 8B, E. H. S. 4B, E. H. S. 1A, will indicate the various classes in the Erasmus Hall High School. S. S. students will be used for students in the summer session at Columbia University. The expressions college students and graduate students will serve to denominate the other classes tested.

It will be seen that the 212 subjects range from the young pupil, whose ability to read and write is barely sufficient to make such an experiment possible, to individuals well on toward middle life, and representing a high grade of scholastic attainment. Inasmuch as most of the graduate students took part in three experiments and the college students in two, I had in all 259 papers in which the various reproductions were complete.

This number may not seem sufficiently large for a statistical investigation, but it must be remembered that the length and character of the tests made them fairly reliable measures of the powers of the individuals. It was not so necessary, therefore, as it would have been in a shorter test, to swallow up errors regarding individual measurements by the mere mass of testimony. On the other hand, only in so far as the individuals tested are typical can the results be said to be universally valid. To the consideration of these results let us now proceed.

THE RESULTS.

These I think it convenient to group in two divisions: *A*, the amounts of loss in the various reproductions and with the various classes of subjects and tests; *B*, the character of this loss in the different cases.

A. The Amounts of Loss.

In order to deal with this matter a method of scoring was necessary. This required analysis of the thought of the pas-

sages — an analysis that is indicated in the passages as printed. The following table gives the standard score of each passage.

	Topics.	Subtopics.	Details.	Words.
The King Who Became Just.	9	20	69	138
Cicero.	9	25	64	125
The History of the Jews.	8	26	80	163
The Dutch Homestead.	8	26	88	180
The Stages in the Development of Human Theory.	7	25	93	171

It must be confessed that this analysis has in it something arbitrary. To say that each of the detailed thoughts thus indicated is equal in value to every other is manifestly absurd. And this is true whether our estimate be based on relative importance to the thought in general or on relative difficulty of recall. But it must be granted that the same objection could be raised against any endeavor to compare two mental conditions quantitatively. However, as the mind of the subject traveled over the thought it was trying to reproduce, it may be conceived to have rested momentarily on each of the details indicated. In general, the better memories could be expected to retain not only the easily remembered details, but also the ones harder to recall, whereas the poorer ones would retain only the former class. In such cases the scores given can not be challenged on the ground that the lack of equality between the units renders the ranking of the subjects arbitrary. Placing different values on the ideas or analyzing the units differently might affect the ranking in cases where the loss of certain ideas is pitted against that of different ones, but seldom, I am confident, could one justify a valuation or an analysis so different from mine as to affect materially the ranking of the student. Hence, the general results of my investigation are, I conceive, not dependent on the peculiarities of my scoring.

The scores given have not been diminished because of errors. They are records only of what was retained. I have taken the ground that the erroneous idea that contains the suggestion of the true one deserves a positive rather than a negative score. It indicates a thought corresponding, however inaccurately, to the earlier one. Such ideas are given a part of the value of an accurate memory. Some individuals, it is true, leave unex-

pressed the hazy idea that they fear is erroneous. They might suffer by comparison with cloudier minds that failed to discover the presence of the fog. However, a mind that feels a certain idea to be inaccurate is usually able to express the part or phase of the thought that is accurate, and thus render a true account of what was in the memory.

In comparing the abilities of different classes of subjects, I have used for the most part the scores made in detailed thoughts and in words. This was regarded as the safest basis for such comparison. If the equal value of the elemental ideas is questioned, much more might that of the subtopics and topics into which the thought of the passage was analyzed. A consideration of the scores in larger thoughts as compared with those in details is reserved for the discussion on the qualitative differences between the different reproductions.

The scoring of words remembered might easily become a complicated matter. Doubtless, the reproducing of certain words means far more power of memory than that of others. I have used the following system. All words of the original that were reproduced in their former contexts were scored full value. Commonplace words, particularly articles, prepositions, and conjunctions, were not scored when reproduced out of their context. On the other hand, an unusual word was regarded as remembered, even though it appeared in the wrong context. Occasionally a word was evidently used because its sound was somewhat like that of one in the original. A half credit was here given. Words that were modified to suit changes in construction, etc., were given partial credit also. Let us now proceed to the comparison of the various records.¹

AVERAGE SCORES OF THE DIFFERENT CLASSES.

Test.	Class.	Ideas.					
		1st Rep.	Av.Dev.	2d Rep.	Av. Dev.	3d Rep.	Av. Dev.
Test I.	S. S. students,	53.0	6.6	48.3	5.6	45.8	6.5
	P. S. 7B pupils,	49.5	6.9	46.5	4.8	41.9	8.2
	P. S. 6B "	45.9	6.0	44.6	7.3	41.3	6.2
	P. S. 5B "	38.3	8.3	36.3	8.8	32.0	7.5

¹ I introduce in the appendix, for the benefit of those who care to examine the numerical data on the basis of which all these computations depend, a list of the individual scores in the various tests.

Test.	Class.	Ideas.					
		1st Rep.	Av. Dev.	2d Rep.	Av. Dev.	3d Rep.	Av. Dev.
Test 2.	E. H. S. 8B students,	42.6	5.1	38.0	6.6	33.5	8.8
	E. H. S. 4B "	38.0	7.5	34.9	9.3	24.9	10.6
	E. H. S. 1A "	36.8	7.9	31.0	8.1	22.8	8.4
	College students,	48.0	8.2	36.5	8.2	34.5	10.3
Test 3.	College "	37.0	4.4	27.0	5.1	24.1	7.2
	Graduate "	42.2	10.2	34.6	10.3	29.5	10.1
Test 4.	Graduate "	57.5	8.8	46.9	8.1	40.6	8.0
Test 5.	Graduate "	45.9	13.2	30.4	8.9	21.8	8.9
Test 3.	12 selected graduates, ¹	44.5	9.9	37.5	9.2	32.9	8.0
Test 4.	12 " "	60.6	7.0	49.0	6.4	41.8	7.7
Test 5.	12 " "	45.6	11.7	30.1	8.6	22.4	9.5

AVERAGE SCORES OF THE DIFFERENT CLASSES.

Test.	Class.	Words.					
		1st Rep.	Av. Dev.	2d Rep.	Av. Dev.	3d Rep.	Av. Dev.
Test 1.	S. S. students,	77.0	13.4	59.0	13.3	52.1	13.2
	P. S. 7B pupils,	70.6	14.1	61.1	12.2	51.1	16.6
	P. S. 6B "	63.9	12.3	59.7	13.9	52.1	14.1
	P. S. 5B "	53.4	13.7	47.4	11.2	40.4	11.2
Test 2.	E. H. S. 8B students,	76.5	9.1	64.6	11.4	55.7	17.0
	E. H. S. 4B "	66.3	16.4	57.9	18.7	44.1	18.8
	E. H. S. 1A "	61.2	16.5	47.8	14.3	32.4	11.3
	College "	82.0	19.5	49.7	18.0	44.2	20.7
Test 3.	College "	43.4	8.2	26.6	8.6	22.3	9.6
	Graduate "	56.5	16.5	37.8	15.5	30.5	14.0
Test 4.	Graduate "	90.9	15.1	66.9	13.9	51.9	9.4
Test 5.	Graduate "	63.7	21.3	39.0	12.8	24.5	11.0
Test 3.	12 selected graduates, ²	60.7	19.2	41.3	17.1	34.9	13.4
Test 4.	12 " "	96.0	12.9	71.0	12.2	53.6	10.5
Test 5.	12 " "	63.2	20.9	39.2	13.2	24.4	11.4

AVERAGE PERCENTAGES OF LOSS IN THE VARIOUS REPRODUCTIONS.²

Test.	Class.	Ideas.			Words.		
		1st Rep.	2d Rep.	3d Rep.	1st Rep.	2d Rep.	3d Rep.
Test 1.	S. S. students,	23.1	8.8	13.6	44.2	23.3	32.3
	P. S. 7B pupils,	28.1	6.0	15.3	48.8	13.4	27.7
	P. S. 6B "	33.4	2.8	7.8	53.7	6.5	18.4
	P. S. 5B "	44.5	5.2	16.4	61.3	11.2	24.3

¹ For purposes of comparison the average scores of 12 students who gave all the reproductions of tests 3, 4 and 5 are given.

² These percentages of loss are based in the case of the first reproduction on the standard score, and in the second and third reproductions on the record in the first reproduction. The object is to ascertain what proportion of the original passage was not learned and what proportion of what was learned was not retained in the second and third reproductions. The significance of these data will be discussed later.

Test.	Class.	Ideas.			Words.		
		1st Rep.	2d Rep.	3d Rep.	1st Rep.	2d Rep.	3d Rep.
Test 2.	E. H. S. 8B students,	33.4	10.8	19.0	38.8	15.5	27.3
	E. H. S. 4B "	40.6	8.1	34.4	46.9	12.6	33.4
	E. H. S. 1A "	42.5	15.7	38.0	51.0	21.9	47.0
	College "	25.0	23.9	28.1	34.4	39.3	46.1
Test 3.	College "	53.7	27.0	34.8	72.1	38.7	48.6
	Graduate "	47.2	18.0	30.0	65.4	33.1	46.0
Test 4.	Graduate "	34.6	18.4	28.6	49.5	26.4	42.9
Test 5.	Graduate "	50.5	33.7	52.4	62.7	38.7	61.5
Test 3.	12 graduates,	44.3	15.7	26.0	62.7	31.9	42.5
Test 4.	12 graduates,	31.1	19.1	31.0	46.1	26.0	44.1
Test 5.	12 graduates,	50.9	34.0	50.8	63.0	37.9	61.3

An examination of the scores in test 1 shows that the total record of each of the different classes of students grows in every reproduction better as we go from the lower to the more advanced classes. This is invariably true of the ideas. In the case of the words the S. S. students fall below the P. S. 6B pupils in the second reproduction; and the P. S. 6B pupils did as well as they in the third reproduction. The older students evidently attended less to words, or at least forgot them more as compared with ideas, than did the younger ones. In test 2 the more advanced classes generally score a better record in ideas remembered, the exception being that the college students fall below E. H. S. 8B students in the second reproduction. In their word record the college students went down even below the E. H. S. 4B students in the second reproduction, and below the E. H. S. 8B students in the third.

It is evident that so far as positive scores are concerned, the advanced students do better as a rule than those in lower classes. At the same time the size of the average deviations in the table of totals shows how unsafe would be a prediction that an individual in a higher class will do better than one in the class below. A comparison of the percentages of loss in tests 1 and 2 shows that between the first and third reproductions the rate of loss is highest with the lowest class, but does not steadily decrease as we approach the higher ones. P. S. 6B pupils suffer the least percentage of loss in test 1, and E. H. S. 8B students remember best in test 2. There is evidently a slight tendency for the more advanced classes to remember better. The heavy percentage of loss of college students in the

second reproduction of test 2 is probably due to the fact that the test was followed by another of the same sort and also by further experiments. This caused it to produce a less profound impression upon them than upon the high-school students, to whom it was a decided novelty.

We can be fairly sure that the more advanced students learn more quickly than those in lower grades. Is this because their memories are better or because their general knowledge and training makes them more readily grasp the contents of the passages, and more effectively address themselves to the task of committing these to memory? If the record of percentages of loss may be taken as the best criterion of excellence of memory, we may be sure that the better average scores of the older classes are not due wholly to this power. It seems to me that this assumption is a safe one. Relative rate of loss will inevitably determine in the long run the relative standing of two individuals in regard to their knowledge of certain common experiences, no matter what portion of these experiences may have originally effected lodgment in the minds of each. Two different scores each diminishing regularly by certain percentages will approach each other continually if the percentages be the same. If they be different, the higher rate of loss will inevitably bring either of the scores to be the lower one, and the memory suffering such loss may certainly be regarded as the weaker one.

It may be objected that the power to retain for a considerable time may be to a great extent independent of the power to remember long enough to reproduce. This point I shall deal with later. If, however, they are, as one might expect, the same at bottom, then it seems likely from the evidence of percentages of loss, that the more advanced students learned more quickly because of knowledge and skill rather than because their memories were better.

In some cases the slight superiority of the older students in power both to learn and to remember is due to the fact that the more advanced classes are made up of students with higher native ability than the lower ones. This result must of course follow from elimination of the weaker minds from the higher

grades of work. In P. S. No. 40, however, the influence of such selection will doubtless be small. It will therefore be of some interest to examine the data from that school, with a view toward determining just how much growth there is from year to year in the powers in question.

Effect of Age and Training on Power to Learn and to Remember.

In estimating the average score of the children of the same age who were tested in P. S. No. 40, I made two calculations. In one all the scores are used, in the other the scores of those who retained less than 50 per cent. of the original matter in the first reproduction were left out. I regard these records as frequently more a result of difficulties in reading and understanding the matter of the test than of lack of a more general ability to learn or to remember. Occasionally an individual who does very poorly at first will retain all he learns. If the power to read and understand were at fault, then the inclusion of such subjects with those who have no such difficulties confuses the factors the influence of which we are trying to determine.

AVERAGE SCORES ACCORDING TO AGE. TEST I.

Age.	S. S. Students.		16.		15.		14.	
	Score.	Av. Dev.	Score.	Av. Dev.	Score.	Av. Dev.	Score.	Av. Dev.
1st rep.	53.0	6	59+	3+	50+	6	46+	6+
2d rep.	48.3	5+	58	5	47+	8	44	8
3d rep.	45.8	6+	54+	8+	43+	8+	39	9

AVERAGE SCORES ACCORDING TO AGE. TEST I (*Continued*).

Age.	13.		12.		11.		10.	
	Score.	Av. Dev.	Score.	Av. Dev.	Score.	Av. Dev.	Score.	Av. Dev.
1st rep.	44+	7	41	9+	45+	6	38+	10
2d rep.	42+	8	40+	9+	43+	8+	37+	10
3d rep.	37+	9+	37+	9	41	7+	34	10+

AVERAGE SCORES ACCORDING TO AGE. TEST I. OMITTING THOSE BELOW 50 PER CENT. FIRST REPRODUCTION (15 IN NUMBER).

Age.	S. S. Students.		16.		15.		14.	
	Score.	Av. Dev.	Score.	Av. Dev.	Score.	Av. Dev.	Score.	Av. Dev.
1st rep.	53.0	6	59+	3+	53+	3+	48	5
2d rep.	48.3	5+	58	5	50+	4+	45+	6+
3d rep.	45.8	6+	54+	8+	46+	6	40+	8

AVERAGE SCORES ACCORDING TO AGE. TEST I. OMITTING THOSE BELOW 50 PER CENT. FIRST REPRODUCTION (15 IN NUMBER). (*Continued.*)

Age.	13.		12.		11.		10.	
	Score.	Av. Dev.	Score.	Av. Dev.	Score.	Av. Dev.	Score.	Av. Dev.
1st rep.	47	5+	48	6	47	6	44+	6
2d rep.	45	6+	45	6	45	6	44+	6
3d rep.	40	8+	42	6+	42	6+	40	9

The ages of the pupils in each grade is indicated as follows :

Age.	16.	15.	14.	13.	12.	11.	10.
P. S. 7B.	2	7	10	9	4		
P. S. 6B.		3	11	9	12	7	
P. S. 5B.			2	8	7	3	6
Total.	2	10	23	26	23	10	6

At first sight it seems that the older students show in general slight superiority over the younger ones so far as scores are concerned. In the later and more reliable table, however, no growth appears between 11 and 14 years of age and the slight advance from 14 to 15 may easily be due to chance. In general, the fewness of the cases renders the evidence decidedly inconclusive, but a comparison of the two tables suggests that the elimination of those who have difficulty in comprehending the passage has destroyed the larger part of the superiority of the older students. In the cases of S. S. students, the better record is to be accounted for because they were doubtless a selected class as compared with the children. Indeed, one is surprised that they do not show more superiority. It will be seen that they are surpassed by the children 15 and 16 years of age. When we compare percentages of loss according to age, we find even less evidence of any growth from younger to older children.

AVERAGE PERCENTAGES OF LOSS ACCORDING TO AGE, THIRD REPRODUCTION, TEST I.

Age.	S. S. students,	16	15	14	13	12	11	10
Per cent. of loss.	14	8	13	15	14	12	10	10

It would seem that the younger pupils remember quite as well as the older ones, or even better. It seems to me that we are justified in suspecting that whatever inferiority they show in power to learn is due to their lack of ability to read and understand readily. An examination of the papers of younger pupils

reveals strange misstatements, that are reproduced literally in the later papers. In a comparatively poor paper by a boy 10 years old in P. S. 5B, we find the passage, 'whose reign had long been a course of savage tyranny. Long had he ruined the rich and distressed the poor,' rendered as follows: 1st repro., 'who had reign over the rich and discreded (?) the poor in dammand (?)' 2nd repro., 'which ruled over the rich in demand (?) of the poor'; 3d repro., 'who ruled over the rich and demanded the poor.' Certainly such mistakes cannot be attributed to bad memory. They are evidence of an unfamiliarity with the words in the text, such as is common in this grade, and has disappeared almost entirely in P. S. 7B students.

Notwithstanding the fewness of my subjects, it seems to me that my results warrant the suspicion that the growth with age of power to reproduce immediately series of numbers, letters, words, etc., established by Bolton, Bourdon, Netschajeff and others, may be due not to growth in power to remember; it is very likely the result of greater ability to understand instructions and the meaning of words, to more familiarity with numbers, and other similar causes. Results ranged according to grades would depend on training rather than age, and the fact that the children of a certain age were in my tests distributed in several grades tended to eliminate the factors of ability and training, and to emphasize such differences, or lack of differences, as were due to age alone. To separate absolutely the effects of age from those of training is, of course, very difficult, if not impossible, and I can claim only to have indicated the probability that training is the more important of the two.

Correlation of Scores According to Ability.

Let us now take up the question of whether power to learn readily correlates with power to remember what is learned. Two investigations may be made, each contributing to the definiteness of our knowledge in the matter. The first will consist in comparing the relative score of each subject in the first reproduction of a certain test with that in the later reproductions of the same passage. The second will compare the

relative percentages of loss of the different subjects in the various reproductions.

The method of correlation that I have used is that employed by Karl Pearson,¹ and in such calculations generally. The percentage of correlation between the scores in two functions of a number of individuals is symbolized by r . The formula for its calculation is

$$r = \frac{\Sigma xy}{n\sigma_1\sigma_2}.$$

Here σ_1 represents the standard deviation of the individuals of a group from the average in one function, σ_2 the standard deviation from the average in the other function. x and y represent the deviations of any individual from the average scores in the two functions compared. The probable error in r is found by the formula

$$\text{P. E. of } r = \frac{0.6745(1 - r^2)}{\sqrt{n(1 + r^2)}}.$$

This is, of course, of importance in determining the significance of estimates based on a comparatively small number of cases.

Correlations of the Scores in Ideas in the Various Reproductions.

The two most important estimates that I have made are based on a comparison of all the scores of the various classes of individuals who took part in test 1 ('The King Who Became Just') and test 2 ('Cicero'). Such a method of combining data disregards wholly the effect of age and training, or of sex, wherever the subjects are of both sexes. It ranks all individuals according to their abilities in learning the passage, and compares this rank with that which they attain in the later reproductions. We do not compare directly power to learn and power to retain, but we find in how far a person will tend to preserve his original rank within the limits of time over which the tests extended. Such a calculation certainly is of some significance.

In test 1 there were 120 who took part. Comparing their

¹ 'Grammar of Science.'

ranking in the first reproduction with that in the second we find that: 8 kept the same rank, 70 lost in rank with an average loss of 6.8 grades, 42 gained in rank with an average gain of 4 grades. The average change in rank of all was 5.4 grades.

Comparing their ranking in the first with that in the third reproduction: 7 kept the same rank, 68 lost in rank with an average loss of 8 grades, 45 gained in rank with an average gain of 6.5 grades. The average change in rank of all was 6.5 grades.

There were 62 grades in the first reproduction, 66 in the second, and 63 in the third. When we reflect that if all the individuals ranged in the 62 grades of the first reproduction had receded to the same level in the second, there would have been an average change of 31 grades, we see that 5.4 grades represents comparatively little shifting. Neither does the average change of 6.5 in the third reproduction indicate anything startling in the way of readjustment in ranking. It must be borne in mind that the difference between two successive grades is usually a half unit out of 69 possible units. Hence the average shifting of from 5.4 to 6.5 grades means very little difference between the scores attained by most individuals and the scores that would have preserved for them their former rank.

Determining more accurately by the correlation formula the amount of regression toward equality in the later reproductions, we find:

Between scores in ideas, first and second reproductions, $r = 96\%$, P.E. = .3%,
 " " " " " " third " $r = 88\%$, P.E. = 1%.

In this calculation, the comparison took account of relative differences between the scores of the various ranks, and the amount of correlation is seen to be even greater than might be supposed from the amount of change in rank.

Considering the scores of the 74 individuals who took part in the 'Cicero' test, we find:

Between scores in ideas, first and second reproductions, $r = 87\%$, P.E. = 1.4%,
 " " " " " " third " $r = 75\%$, P.E. = 2.6%.

It is evident that the lapse of two days produces very little change in the relative amounts of the given passage in the minds

of the various individuals taking the tests. The lapse of a month doubles the discrepancy between the percentage of perfect correlation and the degree of correlation that actually exists. Does this mean that the subjects who learned more quickly will eventually recede in their knowledge of the passage to the rank of those who learned little? By no means. It is true that, if the persons with scores above the average had in general gravitated downward in rank, while those below the average had climbed upward, such a regression to equal rank would have been indicated. But this is not the case. The shifting in rank is seen to be to a great extent among those in various neighborhoods, as it were, in the roll. Many with good records at first get a better standing in the later reproductions. So too, those well down on the list often fall lower. In the midst of this heterogeneity is there any general tendency to regression or the opposite? I do not see how we can tell by merely correlating the actual scores. We may expect these for a time to approach each other in actual size. This, however, would not indicate any tendency for them ultimately to become equal unless the percentages of loss were equal. In this case their relative rank would of course be preserved, while the scores would approach each other. If, however, the percentages of loss be different, it is evident, as we have already noted,¹ that the higher rate of loss, if kept up, will bring the score of the individual who suffers it below that of any other whose percentage of loss is less, — and this no matter how great may have been his original superiority. It follows that, if we wish to determine whether the general tendency is toward regression or the reverse, we must correlate percentages of loss in the later reproductions with the amounts of difference between the standard scores and those in the first reproduction.

Correlation of Percentages of Loss in Ideas.

Between percentages of loss in ideas,

first and second reproductions, $r = 16$ per cent., P.E. = 5.9 per cent.

Between percentages of loss in ideas,

first and third reproductions, $r = 19$ per cent., P.E. = 5.9 per cent.

The percentage was reduced in the case of the third repro-

¹ Page 37.

duction largely because certain individuals who did very poorly at first retained all or about all they had gained. From being at the bottom of the scale in power to learn, they are therefore suddenly elevated to the top in power to remember. Such a radical difference between the abilities involved would seem exceeding unlikely. What is probably the explanation is that the individuals in question found such difficulty in reading and understanding the passage that only a few ideas could be learned, and these were so simple and fundamental in the passage that they were not easily forgotten, in fact, were forgotten by almost none of those whose scores were better. It is unfair to our percentage of correlation to rank such cases as at the top in power of retention. The difficulty created by them can be in a great measure obviated by eliminating from the calculation the scores of those who learned less than 50 per cent. of the original in the first reproduction. It will be remembered that a similar step was taken in comparing the scores according to age. We are left with 105 sets of scores, and the values of r are as follows:

Between rates of loss in ideas, first and
second reproductions, $r = 13$ per cent., P.E. = 5.4 per cent.
Between rates of loss in ideas, first and
third reproductions, $r = 38$ per cent., P.E. = 5.2 per cent.

The positive values of r indicate a constant tendency for those who learn more quickly to retain a greater percentage of what they have gained. Moreover, in the third reproduction this relation comes out more strongly than in the second, indicating that the general tendency is even more apparent with lapse of time. We may be justified in concluding, therefore, that the scores are not tending toward the same goal, but that the majority of those who have done better in learning will continue to retain their advantage.

Again, the elimination of the poorest scores does not raise the value of r between the first and the second reproductions, as it does between the first and the third. On the contrary, the reverse relation holds.¹ The main reason for this is un-

¹ The value of P. E., however, makes the difference of 3 per cent. insignificant.

questionably the much smaller average loss in the second reproduction. Those who lost nothing—or even improved¹—on their second attempt to write out the passage numbered 39, about a third of all; while in the third trial only 17 retained all they had acquired. The poor learners who remembered all had, therefore, much less effect on the value of r for first and second reproductions; and their influence was more than counterbalanced by the effect of the very considerable forgetfulness that some of the poorer ones displayed on this occasion.

Taking independently the various classes of subjects that took part in test 1, we get the value of r between the rates of loss in ideas in the first and third reproductions.

S. S. students, $r = 14.5$ per cent., P. E. = 15 per cent.
 P. S. 7B pupils, $r = 57.8$ per cent., P. E. = 8.4 per cent.
 P. S. 6B pupils, $r = 4$ per cent., P. E. = 10 per cent.

Omitting those scoring less than 50 per cent. of the standard in the first reproduction,

P. S. 6B pupils, $r = 35$ per cent., P. E. = 9 per cent.

Two important features may be noted here: the great advance in the percentage of correlation with P. S. 6B pupils when the four who fell below 50 per cent. in the first records were eliminated; and the excellent percentage shown by P. S. 7B pupils as contrasted with that of S. S. students. The first of these points need not be discussed further. We see clearly the importance of having all subjects able to read and understand the passage. The excellence of the correlation in the case of P. S. 7B pupils is undoubtedly to be attributed to the fact that few of them had these difficulties that swamped a number in lower grades, and also to the general uniformity in training and other conditions that prevailed there. The poorness of the correlation with S. S. students is doubtless due to the fewness of the cases, and to the great diversity among the students. The classes contained both sexes, and the age ranged from young manhood and womanhood to middle life. The training too was

¹ Those who did better in their later papers were treated as having forgotten nothing. No negative losses (positive gains) were considered. Their introduction would have complicated the calculations, and such gains as appeared were slight, and can be neglected without serious error. (See table of results.)

very diverse. Some were college graduates, others not; and while all were teachers, they represented all ranks in the profession from teachers in the primary grades to a college professor. It would have been highly desirable, however, to have got enough such cases to have made certain whether or not the percentage given is the average even for subjects thus diverse in character. My opinion is that r is here too low, and that it should, as elsewhere, range in the neighborhood of 40 per cent.

A consideration of the papers of all classes taking test 2 yields the following results:

Between rates of loss in ideas, first and second reproductions,	$r=4$ per cent., P. E. = 9 per cent.
Between rates of loss in ideas, first and third reproductions,	$r=36$ per cent., P. E. = 8 per cent.

Here again, it will be noted, the loss between the first and second reproductions does not correlate significantly with the original loss. Why should the second reproduction fail to bring out the relation apparent in the third? Two explanations might be given. First, it might be thought that certain individuals in the class discussed the passage in the interval. Such discussion would probably come, if it came at all, immediately after the first experiment, while the matter had the freshness of novelty. Its effect might very well be to fix certain parts much better in the minds of the poorer students. In many cases they might discover mistakes and fill in gaps in their earlier notions of the contents of the passage. The second reproduction, coming close after these discussions, would profit by them. If the discussions were general the poorer pupils would gain most and the better ones least from them, and one might expect no correlation between the losses in the two reproductions, or indeed, an inverse relation.

According to this explanation our values of r between the first and second reproductions are far too small to indicate the truth about the relation we are seeking. Moreover, if discussion on the part of the subjects affected the third reproduction, there too r should be similarly wrong. However, we may suppose that the interval of a month would enable the relative abilities of the various subjects again to assert themselves, so that

the true relation would be more manifest than before. That the longer interval enables the memory to show more clearly its defects and excellencies we cannot question. The third reproduction is, therefore, undoubtedly a better basis for determining the relative amount of forgetting than the second.

I have already indicated my belief that the subjects gained very little from mutual discussion.¹ The fact that some did better in the second than in the first reproduction is not evidence that they got additional information from others, any more than the ability to call up something that on a previous occasion could not be remembered is evidence that one has in the meanwhile consulted an authority in regard to it. Immediately after studying the passage certain parts might be omitted because the attention does not get turned toward them when the reproduction is made. The accident of the moment may bring them to the front later. Often the later reproductions indicate a better perspective in regard to the thought of the passage as a whole than do the earlier ones, where the details and the expression absorb much of the attention. Such a birdseye view may seize on phases of thought that are crowded out of the earlier papers. A study of the gains of later papers will convince one that such explanations as I have just offered will account for them far better than the hypothesis of intervening discussion. At any rate, we may be sure that correlation percentages were very little affected by it. The smallness of r in the case of rates of loss in the first and second reproductions, I account for by the notion that the general loss was so small with the second paper that what might be called accidental forgetfulness had an unusually large influence. Where amounts of loss are slight, differences in them due to the mood of the subject, his physical health for the day or the hour, accidental disturbances of the attention, etc., count for much. These differences are in the later reproduction swamped in the greater loss that is the normal result of the longer lapse of time. On the other hand, the fact that some correlation prevails between the losses in the two earlier papers is significant of the truth of the principle that those who learn quickest usually remember best.

¹ See page 28.

It will be remembered that the scores in the first reproduction correlated better with those in the second than with those in the third. This may seem inconsistent with the fact that with percentages of loss the higher value of r lies between the first and third reproductions. There is, however, no contradiction. An individual who did poorly at first might later remember all he had learned. Such a case would reduce decidedly correlations based on percentages of loss. He might, however, easily retain his rank in the list of scores, especially in that of the second reproduction where the amount of loss is in general small. In the later paper the rank would be more likely to be affected, because the greater general loss would probably result in sending him up the list. In general, it may be said that the rates of loss in the second reproduction, although they correlate poorly with those in the first, are on the average so small that they are swamped by the general size of the scores; while in the third reproduction the rates of loss, though more in harmony with those of the first reproduction, are yet sufficiently divergent and sufficiently large to modify the ranking considerably.

Correlation of Rates of Loss in Words.

In regard to words, I have calculated only two correlation percentages, one making use of all the test papers in test 1, the other based on all the papers of test 2. I have compared the losses in the first reproduction with those in the third only, regarding this as the more significant value. The following values of r were obtained:

Between rates of loss in words, first and third repro-	
ductions,	test 1, $r = .88$ per cent.
Between rates of loss in words, first and third repro-	
ductions,	test 2, $r = 25$ per cent.
	P. E. = 8.5 per cent.

The lack of correlation in the case of test 1 is striking. The percentage is improved by eliminating the fifteen subjects who stood lowest in rank in ideas. These are with two exceptions the lowest in rank in words. The result of this calculation gives

$$r = 16.6 \text{ per cent.}, \text{ P. E.} = 6.5 \text{ per cent.}$$

The powers of learning and retaining words do not go so well together, it would seem, as do those of learning and of retaining ideas. 16.6 per cent. as against 38 per cent. in test 1, and 25 per cent. as against 36 per cent. in test 2, are values of r fairly convincing on this point. However, it must be kept in mind that by many the words were learned rather incidentally. All tried their best on ideas. If little attention were given to the words the amount of the score would be largely dependent on the accidents of expression. Many of those who learned and remembered well departed considerably from the words of the original. Many poor in both these functions did likewise. Those who retained expressions quite literally could also be found scattered among both the good and the poor in remembering ideas. On the supposition that accident determined, in the case of those who made no great effort to be literal, whether the words of the original were used or not, we conclude that its effects would be found in the papers of both the superior and the inferior minds. Distributed in this impartial way, it reduced the percentage of correlation. That the memory for words is doubtless weaker with most people than the memory for ideas, is an additional reason for supposing accident to be influential in determining the score in words.

Comparison of Results in Tests 3, 4 and 5.

So far we have discussed the results of tests 1 and 2. The other tests offer an opportunity for comparing the relative abilities of a number of individuals in different classes of material. Twelve students gave me complete sets of papers in all these three tests. If we correlate their ranking in the different tests we get the following rough values of r :

RANKING IN SCORES OF FIRST REPRODUCTIONS.

- 'The History of the Jews' and 'The Dutch Homestead,' $r = 61$ per cent.
- 'The History of the Jews' and 'The Stages in the Development of Human Theory,' $r = 85$ per cent.
- 'The Dutch Homestead' and 'The Stages in the Development of Human Theory,' $r = 50$ per cent.

RANKING IN PERCENTAGES OF LOSS, THIRD REPRODUCTIONS.

'The History of the Jews' and 'The Dutch Homestead,' $r = -25$ per cent.

'The History of the Jews' and 'The Stages in the Development of Human Theory,' $r = 54$ per cent.

'The Dutch Homestead' and 'The Stages in the Development of Human Theory,' $r = -9$ per cent.

In the first reproduction a decided tendency for those who did well in one passage to do well in the others is evident. Especially is this relation close in the learning of the passages on the Jews and Comte's philosophy. It is interesting to note that only between these two tests is there any significant correlation in regard to power to retain what was learned. An examination of the matter of the tests will suggest the reason. Tests 3 and 5 deal with abstractions as contrasted with test 4 ('The Dutch Homestead'). Wide reading and philosophical study would be apt to help one in learning and remembering tests 3 and 5, while they would be of little value with test 4.

Effect of Method of Learning on the Results.

To the undergraduates of Columbia College I gave test 3 by simply reading it to them slowly, asking for a reproduction as nearly literal as possible. Examining their record, we see that they did a little worse than the graduate students who had the longer period for learning. That they did so well comparatively, is evidence of the great importance of the first reading of a passage as compared with repetitions. The percentages of loss in the later reproductions indicate that the longer period is about equally valuable for fixing the ideas and words and for enabling a more complete immediate reproduction.

A comparison of the ranking in the first reproduction of the 18 individuals who took both tests 2 and 3 shows a correlation of about 37 per cent. When we correlate rank in percentages of loss in the third reproduction, $r = 34$ per cent. It is probable that the different conditions of giving the two tests were largely responsible for the smallness of these values as compared with those obtained from the graduate students in the most favorable cases.

Comparison of Standing in Tests with Teacher's Marks.

For two classes of E. H. S. students and the pupils in P. S. No. 40, I obtained estimates of class standing from the teachers in charge. The 12 E. H. S. 8B students were put in three grades. The 3 who were put in grade I. stood first, fourth and seventh in the first reproduction of my test. The 2 who were put in grade III. stood fifth and tenth in these papers. The correspondence between my records and the estimates of the teacher was, therefore, rather small. The rank of E. H. S. 1A students in the test corresponded much more closely to the teacher's marking. Thirteen were put by the teacher in the same section of the class as that to which my records assigned them. The test records advanced 5 one grade, reduced 4 one grade, and 1 two grades. The class was in history, and it is, therefore, likely that excellence in memory would play a great part in determining standard of scholarship.

With the P. S. No. 40 pupils the following results appear: The 20 best P. S. 7B pupils were graded *seriatim* by the teacher, the others ranked as in grade 21. Grading them similarly according to their rank in my test I find that: Six retained the same rank; 24 gained in rank (average gain = 8.3 grades); 13 lost in rank (average loss = 9 grades); average change in rank of total = 33.7 grades. Between the two rankings the value of $r = 13$ per cent., P. E. = 11 per cent.

The pupils in P. S. 6B were graded *seriatim* by the teacher. Two taking part in my test were omitted in this grading. The comparisons follow: One retained the same rank; 22 gained in rank (average gain = 10.9 grades); 18 lost in rank (average loss = 12.8 grades); average change in rank of the total 41 = 11.5 grades; between the two rankings the value of $r = 22$ per cent., P. E. = 9 + per cent.; P. S. 5B pupils were graded *seriatim*; 16 gained in rank (average gain 5.7 grades); 11 lost in rank (average loss 8.3 grades); average change in rank of total 27, 6.8 grades. Between the two rankings the value of $r = 44$ per cent., P. E. = 10 per cent.

The percentage of correlation is here sufficiently great to warrant saying that there is a tendency for the marking of

teachers to correspond to the ability to learn quickly. On the other hand, the tendency is evidently greatly interfered with, and doubtless by such factors as good conduct, application and reasoning power of the child, all of which are at least partially independent of the power involved in my test.

I have not discussed the relation between teachers' marks and rank in the power to retain. Suffice it to say that a glance at the data indicates that the correspondence is much less than between the marks and power to learn quickly. It is likely that the day-by-day impressions are the dominant ones in determining the judgment of the teacher, and these are dependent on such powers as are evinced best in the first reproduction.

It is notable that the teacher's ranking was by the majority improved in my tests. Fifty-three gained in rank while only forty-one lost. On the other hand, the average rank gained was less than that lost. This would seem to suggest that special performances, or certain excellencies of conduct had bettered the standing of many pupils with the teacher. Such individuals suffered loss of rank in the tests. There were few of them, and they lost more, while the unnoted members of the class, or, perhaps, the lazy or troublesome, had a chance to be graded on mere ability and rose in rank in consequence.

Summary of Conclusions on Amounts of Loss in the Various Tests.

The conclusions reached so far have been largely quantitative, relating to the amounts of loss in the various cases rather than to its character. They may be summed up as follows:

1. The total scores of the various classes in all reproductions and in both ideas and words tend to increase from the lower grades to the more advanced ones.

2. There seems to be a slight increase in power to learn as we go from younger to older students. The evidence indicates that this increase is probably wholly dependent on greater ability to read and understand the passages. The older students do not remember a greater percentage of what they have learned. Training would, therefore, seem to affect more the power to learn than the power to retain.

3. Those who learn quickest retain in general a greater percentage of what they have learned. This holds true of the percentages remembered in both the second and third reproductions, but the rule comes out more clearly in the latter case than in the former. The same law holds between power to learn and to retain words, although the percentage of correlation is not so great as with ideas.

4. Individuals tend to keep the same rank in power to learn in the various tests. In power to retain the ranking was more widely variant. When the material of the two tests was similar it corresponded to a significant extent.

5. A single reading with concentrated attention seems nearly as effective in enabling an immediate reproduction of one of these passages as is three minutes of study. The longer period, however, seems more effective in increasing the percentages both of words and ideas retained.

6. Teachers' marks in grammar grades correlate only to a small extent with the ranking in the tests. In a higher grade, however, where the subject demanded powers like those tested, the correspondence was found to be close.

Let us now proceed to consider the changes in the character of the material in the later reproductions.

B. Character of the Changes in the Later Reproductions.

The investigation of the fortunes of the various factors that enter into our experience in the subsequent history of our consciousness, if an almost hopeless, is at least a fascinating occupation. Certainly most of our purposes in education are dominated by our theories in regard to the ebb and flow of the waters upon which we as teachers cast our bread. If we are to test at all the accuracy of these theories, to penetrate in the least into the complexity of the modifications that memory imposes upon our ideas, we must, of course, be content, at any rate in the early stages of investigation, with examining small patches of experience with a view toward ascertaining the history of the definite cultures planted therein. The reproductions that I have obtained are an approximation, I take it, to a cross-section revelation of successive conditions in the minds of the various individuals tested with reference to the passages in question. By compar-

ing these reproductions, therefore, we should be able to ascertain what the fate of individual ideas may be, and the effect of their destinies upon the general character of the thought of the whole passage involved.

I have approached these complicated matters from four directions, gathering a little contributory information from each study. In the first place, an examination of the words, the underscoring of which indicated the confidence of the subject that they occurred in the original, throws some light on the changes in thought that accompany changes in the power to recognize. Secondly, the study of answers to certain questionnaires that I submitted to the graduate students on the occasion of their third attempt at reproducing the various passages, revealed to me the method by which their thought regarding the contents of the passages unfolded at that time. The third study involved the comparison of the amounts of forgetting of the detailed ideas and of the topics and the subtopics into which the thought of the passages was analyzed. Last and most suggestive of all was the investigation into the specific history of detailed ideas and of topics from reproduction to reproduction. Such a study might be carried on almost indefinitely, and I can only claim to have continued it far enough to be able to formulate roughly the leading kinds of modification that the memories evince.

1. Recognized Words.

It will be remembered that the graduate and college students and those in the summer session underscored in the second and third reproductions the words which they were confident had occurred in the original. With the college students this was imperfectly done, depending apparently on whether the student felt inclined to use the time and effort to proceed to the task of judging how he felt regarding words. In fact, the omission of any scoring cannot be taken even with graduate students as a certain indication that no words were recognized.

The following table indicates the results with S. S. students. They are typical of the others :

UNDERScoreD WORDS. S. S. STUDENTS. TEST I.

Rank in 1st Rep.	Rec. W. ¹ 2d.	Mistakes 2d.	Rec. W. 3d.	Mistakes 3d.	Rec. W. 2d & 3d.	Mistakes 2d & 3d.	Mistakes 3d used 2d.
1	69	12	66	12	44	9	1
2	56	23	38	16	32	9	7
3	65	28	69	26	48	13	3
4	61	10	46	8	39	4	1
5	50	30	21	13	16	8	1
6	18	9	13	9	12	3	0
7	35	8	29	9	28	0	1
8	26	15	8	3	8	2	0
9	—	—	15	2	—	—	2
10	3	4	6	3	3	3	0
11	20	4	11	1	9	0	0
12	67	18	56	29	49	9	5
13	22	12	—	—	—	—	—
14	14	2	8	2	6	1	0
15	27	31	5	10	5	7	2
16	4	2	16	13	4	0	5
17	17	6	20	15	14	5	6
Totals,	554	214	427	171	317	73	34

A large part of the variety shown by the various scores indicates not so much differences in ability to recognize, as different standards in regard to the degree of familiarity that warrants the underscoring of the word. Certain common features appear in the total scores of every class involved.

1. More underscoring in the second than in the third reproduction. It will be noted, however, that this rule has exceptions in the case of individual records.

2. Greater percentage of errors in the judgments in the third reproduction. This rule was far more apparent with the graduate students than in the table given. It will be seen to hold for most of the individuals in that table, however.

3. Of the correctly underscored words a far larger per-

¹The meaning of the scores is as follows: *Rec. W. 2d*, words accurately recognized, 2d reproduction. *Mistakes 2d*, words not in the original but underscored, 2d reproduction. *Rec. W. 3d*, words accurately recognized, 3d reproduction. *Mistakes 3d*, words not in the original but underscored, 3d reproduction. *Rec. W. 2d and 3d*, words accurately recognized in both 2d and 3d reproductions. *Mistakes 2d and 3d*, words not in the original but underscored in both 2d and 3d reproductions. *Mistakes 3d used 2d*, words not in the original, used in 2d reproduction but not underscored, underscored, 3d reproduction.

centage is identical in the two reproductions than of those incorrectly underscored.

4. The errors are less frequent than the correct judgments. This rule is not without exceptions, as will be seen, in individual cases.

5. In general, those who remembered better seemed to underscore a little more freely, although not more correctly, than those who remembered worse.

These results are such as we might expect. They indicate that with the lapse of time there is less feeling of certainty in regard to the words, and more actual error in judging them. Also the words correctly underscored remain to a greater extent the same in both reproductions, while the erroneous judgments concern words more than half of which are different in the two cases. We may infer that with the lapse of time the false judgments would come to surpass in number the correct ones, partly because of forgetfulness of the original words, partly because new words, once introduced, would tend to become familiar and eventually regarded as part of the original text. In this connection the last column of the table is interesting.

If we compare the number of words correctly underscored with the number occurring in the original text that are actually used, we obtain the following results. The scores indicate averages per individual.

		Words Correctly Underscored.	Words of the Original Used.	
S. S. students,	2d reproduction.	32.5	59	55 per cent.
"	3d "	25	52	48 "
Graduates, Test 3,	2d "	8.2	38	22 "
" " "	3d "	9.3	29	32 "
" " 4,	2d "	24.4	67	36 "
" " "	3d "	18	52.5	34 "
" " 5,	2d "	12	39	32 "
" " "	3d "	8.2	24.5	33 "

The difference between the number of words of the original used and that underscored can not be satisfactorily accounted for by supposing a tendency to underscore only striking and important words, leaving out conjunctions, prepositions, articles, etc. While this explanation has some significance, it must also

be said that those who underscored freely marked whole sentences, clauses or phrases. Hence only with the less confident, who have small scores, is the ratio in question affected by the failure to underscore less striking words. When we compare individuals, we note that the number of correct recognitions seems only in the most general way related to the number of original words actually used. The relation is little if any more significant than that between rank in correct underscoring and that in number of ideas reproduced. In the second reproduction No. 12 among S. S. students out of 69 original words used recognizes 67. No. 10 recognizes only 3 out of 47. Ability to remember ideas or to use the words of the original does not correlate to any significant extent with confident and accurate underscoring.

What are we to say in general about this power of recognition? At best it is evidently uncertain, and it grows worse with lapse of time. But while the percentage of errors in underscored words varies in the tests from 9 per cent. to 28 per cent. of the total underscored in the second reproduction, and from 20 to 30 per cent. of this in the third, the words thus erroneously 'recognized' with but few exceptions represent accurately enough the thought. It is plain that the feeling of familiarity with the thought has overspread the attitude toward the words used to express it. On the other hand, there is an increasing loss of confidence, a decrease in the amount of 'feeling of recognition,' and this in turn is justified by the increasing inaccuracy in the underscoring, and by the disappearance from the reproductions of many more of the original words. We note how closely the ratios of correct underscorings to original words used keep to each other in the second and third reproductions.¹ The loss of confidence and the change in expression are doubtless due to the same cause, and this cause is evidently a change in the relations between the thought elements that enter into the passages, rather than a disappearance of these. What is the nature of this change? Some light will be thrown upon it by the testimony of the students themselves.

¹ Compare table, page 55.

2. *Accounts of Introspection of Graduate Students.*

The graduate students were allowed to make at leisure the third reproduction of the passages submitted to them. At the same time they were asked to note the course of their thought as they endeavored to recall the contents of these passages. The following directions were given them with a view toward rendering their reports more congruous and definite.

1. Recall the sketch of *The History of the Jews*¹ that you memorized, noting the contents of your minds as you attempt to get a complete account. Note :

(a) Where images of sight occur in recall. Indicate their character.

(b) Where a 'feeling' of the contents enters in. Indicate as far as you can its nature, and in what form, words or phrase it first takes definite shape.

(c) Where you hesitate and reason out what should enter in. Indicate the line of reasoning and whether you are confident that your results correctly reproduce the original.

(d) In what order the various words and phrases make their appearance.

Make the record a running sketch of the progress of your thought as you endeavor to get as complete and literal an account as you can of the passage.

2. Write as good a record as you can of the contents of the passage, getting the thought and where possible the words. Underscore the words which you are confident occurred in the original.

3. To what extent, if at all, have you thought about the passage between the first and the second reproductions, and between the second and last ones?

As the method of study was by reading typewritten copies of the passages, visual images of these, I thought, might play a prominent part in the recall. Of the eighteen individuals who reported their experience in recalling the passage on 'The History of the Jews,' ten mention the image of the appearance of the paper, and many picture a number of words written thereon.

¹ For the other tests the other titles are to be substituted.

Six report visual images connected with the thought of the passage, as of Babylon, Palestine, armies, people wandering about in Palestine, etc. Four make no report of visual imagery. In the case of the passage on 'The Dutch Homestead,' fourteen out of fifteen report visual images of the appearance of the house. One alone pictured the words, and he only to a slight extent as compared with his experience with the former passage. Two note the absence of the images of printing, etc., noticed before. In the case of the third passage, on Comte's philosophical ideas of the evolution of theories, four out of fourteen report visual images of the paper, etc. None report any other pictures, and five note the absence of visual imagery.

We have here, from the point of view of recall, two types of images. One, that picturing the paper, etc., reproduces the original situation of learning, with a view to recalling its associates; the other reproduces the visual aspects of the meaning of the passages. One person reports an absence of images, but instead a sense of muscular adjustment, strain of attention, etc., which was supposed to be similar to that which accompanied the learning of the passages. Here¹ we have that mental attitude which, as I have before indicated, constitutes the vaguest, most general clue to the recall of any definite group of ideas. With one subject it involved the image of Irving's 'Sketch Book,' with another that of an earlier time when the story was read.

Starting from this general *attitude of attention like that when the passage was learned* with its accompanying imagery of paper or what not, the next ordinary feature in the recall seems to be the thought of the meaning of the passage. This is introduced commonly by a vague, often inarticulate sense of some peculiar feature of the thought as a whole. In the case of 'The History of the Jews,' it expresses itself with various individuals as a feeling of 'reverses of fortune,' 'a struggling people,' 'balanced parts,' 'harassed people,' 'an outline of Jewish history divided into distinct episodes,' etc. In the recall of 'The Dutch Homestead,' this second stage seems with most

¹See p. 24.

to be properly represented by the picture of the house. General 'feelings of content' here are absent, or are confined to a sense of the comfort, efficiency, etc., that characterizes the life of the inhabitants of the 'homestead.' These are not, I imagine, important 'cues' in the development of the recall. With the account of Comte's philosophy, the second phase of recall consisted usually, I should judge, in a sense of the 'three stages,' more or less definitely conceived. Many of the papers got no further than an attempt to realize what these stages are. They were frequently erroneously stated, but the threeness was invariably present. Whenever the individual was acquainted with Comte's speculations, the passage was recognized as an exposition of these, and the consciousness of this constituted a factor in the second phase of recall.

We now come to the consideration of the methods by which this general sense of meaning develops into the details of the reproduction. Two distinct lines of procedure are here apparent. If the passage were well memorized and retained, the general sense of meaning quickly unfolded itself, revealing in their proper order and without much effort the details of the original presentation. Here the sense of words, phrases and their order was frequently of much importance. Several whose memories for words were good relied largely on this mechanical kind of association to carry them on. When the course of the recall was checked, they simply held themselves in an expectant attitude, hoping for the right thought or expression to rise. If the detail came properly, it brought with it frequently a series of the original expressions. The points in the description of the Dutch homestead usually developed easily, rapidly and in nearly their proper order. It was the easiest of the passages to commit, which means that the thought was congruous, and could be embodied in a general picture, all the details of which could fairly well be in the mind at once. Hence they recurred readily when the general image was once in mind.

But often, instead of waiting in a receptive mood for the thought to spring up, the minds of the students went out actively to seek it. They *reasoned* in the details, either from their general notion of the matters with which the passages dealt, or

from their sense of what might fittingly be said in view of the main theme. One individual worked out his reproduction of 'The History of the Jews' from his notion of the 'Divine Providence' shown therein. Another remembered that the Jews were a 'remarkable people' and reasoned to the causes. This procedure was especially important in the case of the passage on Comte's philosophy, where the 'three stages' furnished abundant opportunity for speculation. The reasoning always had for its object filling in some detail or details which the larger, or vaguer, thought of the passage demanded for symmetry or completeness. Its conclusions were tested by their familiarity in the context, but this criterion did not always suffice to keep out details not in the original. Even 'The Dutch Homestead' furnished occasion for logic, as when the thought that such a description should begin with the outside suggests the roof, which is promptly recognized as an initial element in the description.

We may say that the introspective accounts seem to show the presence in most subjects (doubtless in all) of the following steps in recall.

1. A preliminary adjustment of the attention comparable to that when the passage was learned, and accompanied by imagery of the experiences then.

2. A sense of the general meaning of the passage.

3. The unfolding of the details either by waiting expectantly for certain cues to lead to results, or by reasoning from them to the details, and testing these by the criterion of familiarity in the context.

The first of these phases is only externally related to the contents of the passage. The sense of the meaning is, however, especially where the passage is not well memorized verbally, the basis of the recall of most of the details, and it also determines largely the order of their reproduction. Congruity with it is, doubtless, the basis of recognition of thought, sometimes of words. What is its true relation to the details? Evidently it is not *transcendent* of them. It is rather *immanent* in them. Better, it is made up of them. It is a vague consciousness of their presence, and the words we conjure up to

express it are frequently evidence of its composite quality. It is not an abstraction. It is the concentrated essence of the whole. Its generality is due to the suppression of details not by banishment but by absorption. It is the first thing to come up in our minds, because it is the one thing that was growing while every other thing was being thought, and it represents, in fact, *is* their total effect on our consciousness.

To the study of the method by which this meaning is composed I will now turn. It is created out of details, but they are modified through this productive process. They are still further modified when in a later reproduction they are evoked at the bidding of the general meaning. What is the total result of these changes? Is it a minute account of certain fragments of the thought with forgetfulness of others, or is it a fairly complete representation of the larger topics combined with a vague sense of the details which contribute to them.

3. *Comparative Strength of Memory for Details and for Larger Topics.*

I have already indicated an analysis of the passages used into main topics, subtopics and details.¹ This division makes it possible for us to compare on two levels the extent to which the more and the less general elements are remembered. We note, however, that the direct ratio of percentages of loss of details to that of subtopics or topics would be of little significance, because the disappearance of a topic would, of course, involve the loss of the details coming under it. A 50 per cent. loss in topics would *ipso facto* involve about a 50 per cent. loss in details.² The percentage of loss of details would, therefore, surely be greater than that of larger topics. A more significant comparison would be based on the percentages of loss of details within the subtopics that are remembered, and of subtopics within the topics that were retained. The data in the following table were estimated in this manner. The score in the first reproduction is as before the basis for the calculation of the percentages in the third.

¹ See pp. 28-29, 33.

² Not necessarily exactly 50 per cent. loss in details, because different topics have varying scores in regard to details.

Test.	Class.	First Reproduction..			Third Reproduction.		
		Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
		Loss Details.	Loss Subtopics.	Loss Topics.	Loss Details.	Loss Subtopics.	Loss Topics.
1.	S. S. students,	17.3	5.7	2.6	10.3	4.1	0
	P. S. 7B pupils,	31.7	6.6	5.0	8.9	5.9	4.9
	P. S. 6B pupils,	20.3	8.7	8.3	2.1	6.4	1.4
	P. S. 5B pupils,	23.9	14.8	12.3	7.0	9.9	3.7
	Better P.S. 6B ¹ pupils,	20.0	8.1	4.8	2.2	6.4	1.4
	Better P.S. 5B pupils,	17.6	13.6	5.8	6.8	10.2	4.1
2.	E. H. S. 1A students,	22.9	15.5	8.6	11.8	10.6	21.7
	E. H. S. 4B “	17.8	15.3	11.7	9.1	9.8	18.1
	E. H. S. 8B “	39.2	10.1	3.7	9.5	4	8.6
	College students,	13.4	8.9	4.2	10.4	7	12.7
3.	College “	31.7	20.8	15.4	14.1	15.9	9.5
	Graduates,	19.3	15.8	18.7	9.9	16.9	3.8
4.	Graduates,	18.1	17.5	0	17.6	12.0	5.2
5.	Graduates,	25	19.5	17.8	25.6	13.3	17.4

In every case the percentage of loss of topics in the first reproduction was less than that of details, and in 11 out of 12 cases it was less than that for subtopics. In the third reproduction of tests 1, 3, 4 and 5, the topics suffered a smaller percentage of loss than the details. The subtopics invariably lost a smaller percentage than the details in the first reproduction, and in 7 out of 12 cases in the third. In test 2, where the topics lost heavily in the third reproduction, the subtopics lost less than the details in 3 out of 4 cases. We may therefore say that the details disappear rapidly, leaving a comparatively large percentage of the leading topics, which are in the reproductions rendered by a few representative details. The idea of the passage becomes generalized. Of course, there is a limit to this generalization, beyond which further loss of details leaves nothing that can become articulate in a reproduction. Here the loss in topics must equal that in details.

If we were to eliminate the subtopics from the calculation, we would find that in every case the percentage of loss for details would be far in excess of that for topics. When we consider that in the tests there are about as many details in each topic as there are topics in each test, such a comparison will seem a fair one. A second tendency may be noted, which, although probable, could hardly have been so confidently pre-

¹ Omitting those below 50 per cent. first reproduction.

dicted as the first. In both test 1 and test 2 the more advanced students seem usually to suffer smaller loss in topics and sub-topics than the younger ones. The perfection of this generalization is interfered with by the excellence of E. H. S. 8B students (a select class) in topics, and by a large loss in topics by P. S. 7B pupils in the third reproduction. The superiority of the more advanced students in grasping and retaining the general meaning of the passage even when they lost as large or even a larger percentage of details is, however, unmistakable. Age and training, especially the latter, have doubtless something to do with this, although the exclusion of inferior minds from the more advanced classes may partly account for it.

4. *History of the Ideas Regarding the Contents of the Passages.*

Can this same generalizing tendency be discovered in the later rendition of specific ideas in the passages? The general ideas, we agree, tend to be preserved better than the details. But they are themselves made up of details. Some definite content is necessary, or we could not recognize the topics. What details remain that we may identify the larger thoughts? Do they suffer transformation? What details are lost? Are they utterly lost? The answer to these questions should enable us to tell not only whether the memory of such passages is a memory for general ideas rather than for details, but also whether there is, as it were, a *generalization* of the details. If such is the case, then we should be able to offer a description of the process of generalization.

The method of my study has been to follow the fate of particular ideas and contents from reproduction to reproduction. The three reproductions were placed side by side in parallel columns. The parts of each that deal with specific portions of the original were kept as far as possible on the same horizontal lines. Whatever transpositions were necessary to effect this arrangement were indicated. On such a paper the modifications in later reproductions are readily apparent. A plausible explanation for most of them is equally easy. But a classification of the changes by which they may be accounted for is, I

have found, somewhat complicated. For the sake of avoiding too much detail and confusion, I shall present a simple statement of the general character of the modifications, as I have come to conceive them. I shall then discuss one of the passages, pointing out characteristic transformations of each part. This will be followed by a comparison of the differences between the modifications of the different passages, and a record of the extent to which different parts of the passages were retained. Finally, a comparison of these records in the case of P. S. pupils will enable some further deductions as to the effect of age and training on the generalizing power.

a. Types of Changes in the Reproductions.

These changes may be summed up under three heads: regrouping, simplification, introductions.

Regrouping.—The topics and subtopics which are most closely allied tend to be brought together, even when they were treated in separate portions of the original text. The kinship may be a result of some sameness in details, or may lie in the general similarity of the two topics, or in their being complementary parts in the treatment of some general theme. Examples are as follows: In the account of the Egyptian king, topics 4 and 9 are often combined. One is 'when asked by a favorite the reason for this change, he replied'; the other gives the moral of the story, — *i. e.*, the reason for the change. In the account of Cicero, ^{topic 1} subtopic 2—the statement of Cicero's position among Roman orators—is frequently combined with topic 5—the comparison of Cicero's oratory with that Demosthenes. In the outline of Jewish history, the conflicts of the Jews with neighboring tribes, topic 5, and with the nations of the Euphrates, topic 7, are often brought together.

Illustrations might be multiplied. These will serve to make my meaning clear. Such transpositions might be expected, and, as a matter of fact, they take place on a large scale. Often a subordinate detail in one context will be reproduced in another connection where it fits, and the original context, thus disrupted, if it cannot be dragged after its wandering member, may be forgotten. Thus the gradual rise of the Jews 'to the

rank of a powerful, opulent and commercial nation,' topic 6, is assimilated with their increase 'so rapidly as to become on a sudden the fierce and irresistible conquerors of their native valleys,' topic 3. Here the contradictory or inconsistent ideas of course disappear.

Simplification. — The last illustration involves not only re-grouping, but assimilation with condensation and modification of the details involved. Thus the passage becomes simplified. The general result of this process is to force to the front certain striking central thoughts, and to make the other details more closely dependent upon them, and so less conspicuous. Taking up the two specific factors in the process, let us deal with (1) *condensation*. Two types of this appear. First, ideas that are repeated receive only one expression. We have seen that a similarity of ideas will frequently cause two or more separated contexts to coalesce. Here the similar ideas will, of course, usually be expressed but once. The Jews are said to be in servitude to the Egyptians, subtopic 6, to neighboring tribes, subtopic 15, and to the Babylonians, subtopic 23. In several cases these ideas coalesce; *e. g.*, 'sometimes enslaved by the Babylonians, Assyrians, Egyptians,' etc. Again the Jews are said to be 'twice exiled and twice restored to their country,' thus uniting topic 2 with 7, and 3 with 8. Similarly in test 2, 'orators,' subtopic 2, and 'oratory,' subtopic 11, are frequently a basis for condensation of expression, and in test 4 'lowly sloping roofs' makes 'low-projecting eaves' unnecessary.

The second type of condensation is the omission of unimportant words by substituting words for phrases, or clauses. 'In the annals of mankind,' test 3, becomes 'of the world,' 'of mankind,' etc. 'Placed side by side with Demosthenes, or, at least, close after him,' test 2, becomes with slight loss 'placed second only to Demosthenes.' 'Through the ranks of Roman official service' becomes 'through the official ranks,' Roman being understood because the idea was brought out before. 'Suddenly he changed his course and ruled so well as to be called the just,' test 1, becomes 'suddenly he so changed his course as to become known as the just.' 'Was struck on the

head by a stone, that cracked its skull. The stone was thrown by a man' is rendered 'whose skull was broken by a stone thrown by a man.' 'Asked the reason for this change' becomes 'asked why.' 'Government and code of laws totally different from those of any other rude or civilized community,' test 3, appears as 'most peculiar government and laws.' The phraseology thus omitted indicates relations that stood for the special line of march of the thought of the writer of the passage. But the meaning in the mind of the subject is composed of all the points of view gained as a result of this journey. Because they are all in the mind vaguely when the passage is about to be reproduced, they need not be reached by the tortuous paths by following which they originally came to view. The memory inevitably condenses. It is important to note that this condensation is to a very great extent no real loss.

(2) *Modification*. — Regrouping and condensation frequently bring about certain modifications. Often ideas having somewhat the same functions are 'fused' into a new product partaking of the nature of each of its parents. For example, 'whose reign had long been a course of savage tyranny. Long had he ruined the rich and distressed the poor,' test 1, is rendered, 'who ruled the rich tyrannically and the poor harshly.' Here the number of distinct details (according to my scheme of scoring) is reduced nearly one half, but only one significant idea — that of the length of the tyranny — is, I should judge, clearly lost. 'Ruling tyrannically' when applied to the rich does fairly well for 'reign,' 'ruined' and 'tyranny.' 'Harshly' gives us a fair compound for 'distressed' and 'savage.' 'Course' is unimportant. The sentence, 'His family was of the middle class only and without wealth,' test 2, becomes in several instances something like 'His family was of moderate means.' Here 'middle class' is lost but 'moderate' and 'means' testify that the thought has not utterly failed to influence the result. In the same passage 'only' was frequently lost. By way of compensation for one negation, another, the lack of wealth, was emphasized. The family is declared to be 'by no means,' 'not at all,' or 'not in the least wealthy.' In test 3 one paper fuses 'sprung from one stock they pass the infancy of their nation in

a state of servitude in a foreign country' into 'having their origin as slaves to an alien race.' 'Sprung' and 'infancy' unite in 'origin,' while 'race' is more akin to 'stock,' an omitted word, than 'country' for which it is substituted.

Sometimes ideas are in consequence of appearing in a new context modified so as to fit therein. Here the idea suffers in its integrity, not to preserve another that would else be lost, but to save itself. Cicero is said to have been 'bitter' instead of having a 'venomous bite,' the context of the latter statement having disappeared.

Modifications are sometimes made in order to make the ideas consistent with the experience or preconceptions of the individual. The 'stages' of Comte are converted into a variety of schemes; *e. g.*, 'metaphysical or speculative, ethical or religious, and scientific or exact.' The 'favorite' of the Egyptian King becomes a 'servant,' a 'friend,' 'one of his people,' etc. The 'fox,' a strange animal to city children, becomes a 'pig.' 'Trod on,' an unfamiliar expression in test 1, is translated into 'trampled on,' 'run down by.' In the last instance the fusion with 'ran in the way of' and 'kicked by' (used in an earlier reproduction) is evident. 'Changed his course and ruled so well, etc.,' becomes 'changed his unjust rules,' rules being a prominent idea to the much governed school-child.

Of course, there is a great deal of downright omission in the reproductions. It usually takes place first with the insignificant ideas. They are lost largely because rearrangements have rendered them useless or incongruous. The notable thing is the extent to which all ideas that contribute any marked share to the thought which may be said to constitute the total sense of the passage leave some evidence of themselves. This matter I shall discuss quantitatively later.

Introductions. — One of the most evident peculiarities of the reproductions is the extent to which certain expressions or thoughts are made to do service as substitutes in other contexts than that in which they originally occurred. Situations at all familiar are described as nearly as can be in the same terms. This similarity of expression leads, of course, to greater sameness of thought than existed before, and aids in the generaliza-

tion of the passage. The 'tyranny' of the Egyptian King is called 'injustice' because his later conduct made him called 'the just.' This change is a type of a very common mode of treating this part of the passage. One subject carries the thought of justice and its opposite so far that 'ruining the rich and distressing the poor' becomes 'condemning the innocent and oppressing the righteous.' Again '*trampled on* the poor' instead of 'distressed the poor' is doubtless influenced by the later 'trod on' by a horse. In the Cicero test the word 'rank' was frequently used in comparing the Roman with Demosthenes, a context where it does not appear in the original.

The Jews are said to be 'remarkable without reference to their religious belief.' Later when their 'government and laws' are mentioned, these are declared to be 'remarkable' in lieu of the original characterization. The papers teem with illustrations of introductions. From the point of view of the context into which they force their way, they are often really modifications. Certain ideas lie in the foreground of the general thought which the subject is trying to sketch in his reproduction. These thrust themselves into any congruous situation that the sketch presents, and usurp the place of those original ideas the function of which they can perform. All this results in greater similarities, which in later reproductions are a basis for a new regrouping and consequent simplification. Thus the generalizing process feeds itself. It spreads through the passage similarities more nearly perfect than those in the original, and these serve to bring about new combinations in which the remaining differences tend to disappear. In this fashion that general picture which may be regarded as the final product is evolved.

But it has not so much annihilated as devoured the distinctions by the suppression of which it has been forced to the front. It has fed on them, and its substance is not without trace of the matter out of which it has been composed, as well as of the directing ideas by which this has been disposed. Omissions do, indeed, reduce the richness of content in the passage. Introductions tend to chase out differences, and to leave the prominent ideas in possession of the field. Nevertheless, it must be

remembered that the modifications and condensations of simplification for the most part squeeze out only the water, leaving the essence of the thought.

b. Modifications in the Reproduction of
'The Dutch Homestead.'

Let us now take up one of the passages and run through some of the characteristic changes that different parts of it undergo. 'The Dutch Homestead' I have chosen as, perhaps, offering the most suggestive material for study. Some account of ways in which its specific parts came to be rendered appears in the column parallel to that containing the original. The numbers indicate the division into subtopics, and the comment concerning each subtopic occupies the space opposite.

<i>Original Text.</i>	<i>Comment of Typical Modifications.</i>
1. It was one of those spacious farmhouses	The formal introduction 'it was' is preserved in 37 out of 45 papers. Probably under the influence of the idea of 'lowness' later brought out, 'spacious' is rendered 'wide,' 'long,' 'rambling,' etc.
2. with high ridged but lowly sloping roofs,	'High' is frequently left out because of 'lowly.' We find all adjectives sometimes condensed into one; e. g., 'peaked,' 'steep.'
3. built in the style handed down from the first Dutch settlers,	This entire statement is often condensed to such a form as 'old-fashioned Dutch farmhouse,' and transferred to the beginning of the passage.
4. the low projecting eaves forming a piazza along the front	This context is usually combined with that of 'lowly sloping roofs.' The adjective 'long' is applied to the piazza. I conjecture the influence of the sound in 'along' plus the thought of the proportions of the house.

5. capable of being boarded up in bad weather. We find 'bad weather' mentally contrasted with 'summer,' subtopic 9, and called 'winter weather'; or the porch is declared to be for winter use.
6. Under this were hung flails, harness, The word 'hung' occurs in yet another context, subtopic 25. As a result it is introduced wherever it can be.
7. various utensils of husbandry, This is a summarizing expression that rarely leaves no trace on the reproduction. Its influence is seen in such expressions as 'various articles of furniture' said to be in the hall.
8. and nets for fishing in the neighboring river. This is an idea so out of harmony with the general thought that it is more frequently left out than any other subtopic.
9. Benches were built along the side for summer use, We find the porch called a living place in summer to contrast with the hall, which is the 'principal place of residence.'
10. and a great spinning wheel at one end Spinning wheel is frequently transferred to the hall because naturally connected with 'wool ready to be spun,' etc.
11. and a churn at the other This leaves the churn at one end of the porch with nothing to balance it at the other. Various articles are used to fill in the gap, 'settee' being one.
12. showed the various uses to which this important porch might be devoted. We find all the articles from harness to churn grouped and said to indicate the occupations of the people dwelling here.
13. From the piazza one might enter the hall The hall is often called 'large' from the influence of 'spacious'

- and 'mansion.' When called 'the central hall' the next subtopic is omitted.
14. which formed the center of the mansion Subtopics 14 and 15 are often combined; *e. g.*, 'the spacious living room.'
15. and the usual place of residence. The word 'usual,' similar in sound to 'use,' doubtless aids the generalization of the details of subtopics 9 and 15.
16. Here rows of resplendent pewter I find 'resplendent' or some equivalent word often transferred to 'red peppers,' subtopic 26.
17. ranged on a long dresser The piazza is 'along the front,' the benches are 'along the side,' and later the festoons are 'along the walls.' Hence the pewter is often put 'along a dresser.' In one case we find two dressers mentioned.
18. dazzled his eyes. The idea of 'dazzled' is usually absorbed in that of 'resplendent.'
19. In one corner stood a huge bag of wool 'Huge' and 'bag' are used indifferently with either 'wool' or 'linsey woolsey.'
20. ready to be spun. Omitted frequently. Possibly it is absorbed into the idea of the spinning wheel.
21. In another a quantity of linsey woolsey The idea of 'linsey-woolsey' is somewhat unfamiliar, but it almost holds its own with that of 'wool' in the reproductions.
22. just from the loom. In one case this is combined with subtopic 20, as 'ready to be used.'
23. Ears of Indian corn The idea of 'corn' suffers some transformation frequently. It becomes 'dried vegetables,'

- ‘other dried fruits,’ because of the dried apples and peaches.
24. and strings of dried apples and peaches Almost invariably some fruit was mentioned although not always apples and peaches.
25. hung in gay festoons along the walls, The ‘festoons’ are often left out, and ‘gay’ unmentioned in the general brightness.
26. mingled with the gaud of red peppers. The ‘red peppers’ are sometimes absorbed into the dried stuff generally. In one case they are called seed-pods, perhaps combining with corn, as several speak of the latter as ‘seed corn.’

I have thought that the exhibition of a typical series of reproductions would have the advantage of showing such modifications in the specific context in which they occur. Thus the total effect of such changes can be better seen. In the columns that follow the reproductions of one student are placed side by side. Each numbered section indicates the material of the reproductions on the corresponding subtopic in the passage. Whatever the arrangement of the subject, the treatment of each subtopic is, therefore, introduced in the order of the original passage. That the transpositions might be evident, however, every expression that in the subject's version did not follow directly after the one that in our version is put just before it is introduced by a number and the sign +. This number indicates the section where may be found the matter that in the reproduction did actually precede it. The sign + and a number following the matter of a section indicates the section where we may look for the text that in the subject's version appeared next in order. The numbers are therefore guide-posts that will serve us in reintegrating the passage as it appeared in the reproduction. A number introduced parenthetically indicates the section where the word or idea preceding it may be found in the original passage.

First Reproduction.	Second Reproduction.	Third Reproduction.
1. It was one of those spacious farmhouses	The farmhouse +3	The Dutch (3) homestead
2. with high ridged but lowly sloping roofs	3+ a low rambling structure with low +4	was a large low house with sloping eaves.
3. built in the style of the early Dutch settlers,	1+ of the early Dutch settlers was +2	
4. the drooping eaves of the roof formed a piazza,	2+ overhanging eaves under the shelter (5) of which was a piazza running around the house +10	reaching almost to the ground underneath which was a piazza +12
5. which might be closed in bad weather.		
6. From the rafters hung flails, harness	9+ and hanging from the piazza roof (2)	11+ harness +8
7. and other farm utensils,		
8. nets for fishing in the neighboring river.	nets for fishing and sets of harness (6) +12	6+ and nets for fishing in the river +13
9. Along the house were ranged benches for summer use	11+ benches for the use of the family in summer, +6	12+ Here in summer time the family lived and upon it were placed in various positions wash benches +11.
10. and a huge (19) spinning wheel at one end	4+ Here was placed +11 (cf. 19)	21+ a spinning wheel +25
11. and a churn	10+ a churn +9	9+ churns +6
12. showed the various uses to which the piazza might be put.	6+ showed the varied uses to which it was put.	4+ which served a variety of usages +9.
13. From the piazza one might enter the hall	From the piazza one entered	8+ Entering the house
14. which formed the center of the house	the central hall	in the middle was a large hall
15. where the family lived.	the living room of the family.	the living room in winter for the family and a storage place for various (7) useful articles.
16. Here rows of resplendent pewter	Here	Here
17. ranged upon dressers		
18. dazzled one's eyes.		
19. On either hand hung (25) wool	stood the spinning wheel (10), wool	were placed or hung (25)
20. ready for the wheel	ready for the carders	
21. linsey-woolsey	linsey-woolsey	in large quantities, linsey-woolsey +10

First Reproduction.	Second Reproduction.	Third Reproduction.
22. just from the loom +24	just from the loom +24	
23. 24+ and ears of In- dian corn +26	26+ and Indian corn +25	25+ with ears of golden corn +26
24. 22+ rows of dried apples and peaches +23	22+ rows of fruit +26	
25.	23+ shone resplendent (16) along the walls.	10+ and the walls were re- splendent +23
26. 23+ bunches of red peppers.	24+ of brilliant red pep- pers +23.	23+ and clusters of red peppers.

Characteristic regroupings, condensations, fusions and introductions are here evident, as is also the generalized nature of the result. The score in ideas of the third reproduction, I make 37 + out of a possible 88. Of the 50 + details recorded as lost, only 21 that seem to me definitely contributory to the idea have left no clear trace. Doubtless, evidences of many of these have escaped my observation. At any rate, it is certain that the passage is reduced largely by the omission of non-essential elements, and that this condensation is favored or, indeed, brought about by the processes we have discussed. Let us now compare the extent to which these changes prevail in tests 3, 4 and 5.

c. Comparison of the Generalizing Processes in Tests 3, 4 and 5.

Let us note the fate of the topics in the third reproduction. Collecting data from the papers of twelve individuals who took all three tests, we find that in test 3 ('The History of the Jews') an average of 22.9 per cent. of topics was lost; in test 4 ('The Dutch Homestead') an average of 5.2 per cent. of topics; and in test 5 ('Stages in the Development of Human Theories') of 32.1 per cent. The manifest superiority of the memory for the leading ideas in test 4 arises, doubtless, partly because of the simplicity and interest of the thought as contrasted with the more involved and less familiar ideas in the other tests, particularly the one on Comte. The main reason, however, is, I am confident, the fact that, largely because of their greater abstractness, tests 3 and 5 were much more readily generalized through

regrouping, condensation and the introductions that favor such changes. They are filled full of repetitions of words and ideas more or less similar. The same themes are in different contexts several times dealt with from slightly different points of view. Such ideas, whether leading or subordinate ones, tend to receive one expression, and thus to disrupt the passages, thereby initiating all sorts of modifications. Let us notice the nature of the topics in these tests, and the way in which the loss is distributed among them. In the following table the subjects of the various topics are summarized, and a record made of the number of times each is absent in the twelve papers of the third reproduction.

Topics.	The History of the Jews.	Loss.	The Dutch Home- stead.	Loss.	Comte's Phi- losophy.	Loss.
1 Jews remarkable apart from religion.		1	Style and external ap- pearance.	0	Method of reaching the law.	4
2 Origin, and early for- eign servitude.		0	The porch.	0	Its proof.	7
3 Rapid increase, and conquest of Palestine.	0		Contents of porch hanging up.	1	Law as applied to con- ceptions.	1
4 Settlement. Character of government.	3		Contents of porch on the floor.	0	Statement of the succes- sive conditions.	1
5 Conflicts with neigh- bors.	5		Position and use of hall.	0	Law as applied to meth- ods of philosophizing.	3
6 Union, and rise to prosperity.	4		Pewter.	2	Law as applied to sys- tems of philosophy.	8
7 Discord, and conquest by Babylonians.	3		Wool and linsey-wool- sey.	1	General relation of the three stages.	3
8 Restoration to native land.		5	Corn, dried fruit, and peppers.	1		

Examining the record in test 3, we notice no loss in topics 2 and 3, little in 1, and most in 5 and 8. Do our theories afford any explanation of this? The Jews are on three occasions said to be conquered: in topics 2, 5 and 7. Their institutions are characterized in 1 and 4. Their rise to prosperity appears in 3 and 6. Return to Palestine is mentioned in 3 and 8. It will be seen, therefore, that topics 1, 2 and 3 give the important themes of the passage, which the later parts develop in different conditions. Hence the loss in the latter part, where these themes are reiterated. Topic 5, which expresses conflict, victory and servitude, disintegrates easily under the influence of

such other contexts as deal respectively with slavery and conquest. Topic 8, even because of its phraseology, is easily assimilated with 3.

In test 4 conditions are different. The themes stand out from each other, and the main factors of the homestead are invariably given. We find transpositions in the interest of unifying the treatment of the topics, but the topics themselves do not disappear by assimilation, because they are not capable of this. The loss is centered entirely upon different elements in the contents of the house. Twice the pewter disappears, but not without leaving vestiges of the thought of the topic here or elsewhere. A loss in this passage is far more apt to leave a sensible gap, that insistently demands filling, than one in either tests 3 or 5.

The first two topics in test 5 concern the means of discovering the law and the method of proving it. These, it will be seen from examining the passage, are not much different. The means of discovery are the methods of proof. Hence the two topics frequently coalesce. The central thought of the meaning of the passage is, however, given in topics 3 and 4, one of which states the law as one of three stages, and the other characterizes these stages. Each of these topics fails to appear but once in the papers under discussion, and the idea of the three stages is never absent. Into this core nearly all the rest of the passage can be without much loss generalized. What went before indicated the necessity of the law from the very nature of man and from the evidence of experience. This statement of the stages as *necessary* ones in the *history* of human thought embraces all this. The two subsequent topics merely reiterate the fundamental thought. The distinction between methods of philosophizing and systems of philosophy escaped the memories of most. The last topic, bringing out the mutual relationship of the three stages, is better retained because it is more clearly a new point.

I do not think it too much to say that the difficulty in the way of remembering abstractions is not so much the trouble we have in seizing them as the ease with which they coalesce into unity. The 'Logik' of Hegel is a marvellous example of the

way our generalizing power reconciles differences in the sphere of the conceptions. To keep in mind the mass of distinctions therein contained, one must embody them in concrete material or rely on mechanical memory. It is such practices as these that make the abstractions familiar, and force them to stand out in such a way as to resist the difference-annihilating power of the general meaning.

On the other hand, the detail that is least consonant with the general thought, least likely to spring out of an endeavor to reinstate congruous elements, is the one most commonly forgotten. In test 4, 'nets for fishing,' etc., disappears in twelve out of fifteen cases in the third reproduction. And this, doubtless, because we do not think of farming and fishing together. But by the way of comparison, we note that 'ready to be spun' disappears in eleven out of the fifteen instances, and very likely because the introduction of the spinning wheel with the context has satisfied the feeling of need for such an idea. Here we have not the forgetting of the incongruous, but the absorption of the similar. Again, we note that in the fifteen papers 'just from the loom' is missing in eleven cases, 'dazzled his eyes' in eleven, 'ears of Indian corn' in nine, and 'various utensils of husbandry' in eight.¹ We may be sure, if we think, that linsley-woolsey is a home product and 'just from the loom,' that the 'resplendent pewter would dazzle the eyes.' 'The various utensils of husbandry' are like an *etc.* after 'flails' and 'harness,' and the subsequent enumeration of other articles would satisfy the demand for such an idea. The corn disappears in the generalization of 'dried fruit' that blankets the last topic. On the other hand, no one of the notions of the roof, the porch, the flails and harness, the spinning-wheel, the churn, the hall, the pewter, the dresser, the wool, the dried fruit, or the festoons is absent more than three times, many only once, and roof not at all. These were ideas that did not generalize and at the same time were consonant with the notion of such a farmhouse.

In test 3 ('The History of the Jews') the shattering of the

¹ This count is based on the presence of the idea in its original form, and not on any trace of its presence.

subtopics under the influence of the generalizing process is so extensive as frequently to destroy the sense of many of the leading movements involved. If we were to sketch the thought in terms of the ideas that are represented in the majority of papers, it would be: The Jews were remarkable; they were in servitude; they conquered the inhabitants of their native land; they established a peculiar government; they grew powerful; they were again enslaved and restored to their native land. Here all subtopics have been condensed so as to leave just enough to characterize leading ideas. In several cases further condensation is effected by assimilating the conquest of and the restoration to their native land that followed the Egyptian and Babylonian captivities respectively. The special peculiarities of the two contexts have yielded to the generalization that the likenesses invite. Modification or omission is, therefore, their fate. Often enough, however, the minor points disappear because they are themselves similar to ideas elsewhere introduced. The increase in numbers of the Hebrews in Egypt, subtopic 7, is clearly brought only in one case. Elsewhere it is evidently assimilated with growth in power under a monarchy, subtopic 18. 'Neighboring tribes,' subtopic 16, is absent in only four out of twelve cases. Generalization saved instead of destroying it, for it was a good substitute either for the inhabitants of the 'valleys in Palestine' or for the 'monarchies' on the Euphrates. However, these ideas suffered in their integrity, and the topic to which 'neighboring tribes' belongs disappears clearly in five cases out of twelve, destroyed probably because of the employment elsewhere of its constituent ideas. The opportunities for such disintegration in the passage under discussion are so numerous that any adequate description of them must be exceedingly tedious. Let us dismiss the subject by recalling the fact that in spite of their greater loss in topics, the third reproduction of both 'The History of the Jews' and the passage on Comte suffered a larger percentage of loss in subtopics within the topics that remained than did that of 'The Dutch Homestead.'

It will also be remembered that the ranking of twelve students in percentages of loss, third reproduction, corresponded

fairly well in tests 3 and 5, while that in test 4 agreed to an appreciable extent with neither of the others. In the first reproductions also the rankings in tests 3 and 5 show the greatest value of r . The students who handled tests 3 and 5 well constitute, therefore, a common group, the superiority of which does not seem so manifest in test 4. How shall we explain this? One can scarcely doubt that it lies in the supposition that those whose training in the more abstract distinctions involved had been sufficiently extensive to make these stand out sharply gained an advantage in tests 3 and 5 that they did not possess in test 4. Of course the factor of natural ability must be considered, but it is hard to suppose that natural ability accounts for remembering abstractions well and more concrete matter poorly. Training seems to be the only satisfactory reason for the difference. Nor can we suppose that this training improved the power to seize the abstractions as much as it did the memory for them. In the first reproduction abilities in tests 3 and 5 correspond only a little better with each other than they do with that in test 4. But the contrast is striking in the third reproduction. The effect of training, I conceive, is to fix distinctions of an abstract character in such a way — whether by embedding them in concrete material or otherwise — as to make them resist more effectively the generalizations that memory inevitably sets on foot. Some further contributions on this point may be gained from the papers on test 1, where adults and children took part.

d. Comparison of the Generalizing Process in Adults and Children.

It will be remembered that the memory for topics was far better with S. S. students than with any class of P. S., No. 40 pupils.¹ They showed far greater power of seizing the general elements of the passage, and of retaining them, even at the expense of greater percentage of loss of details within the topics retained, than was suffered by the younger subjects. More light is thrown on the reasons for this by a consideration of the topics and subtopics retained by the various classes who took part in test 1. The following table offers the data in regard to

¹ See pp. 62-63.

the topics. The record is of the total loss in the third reproduction as compared with the original passage.

Contents of Topics.	27 S. S. Students.	33 P. S. 7B Pupils.	43 P. S. 6B Pupils.	27 P. S. 5B Pupils.	Totals.
1. The king and his country,					0
2. His tyranny,		5	2	7	14
3. His reform,		7	4	4	15
4. Question of his favorite,		1	4	4	9
5. Story; dog kills fox,			2	1	3
6. Man hits dog,		2	4		6
7. Horse treads on man,	1	1	2	3	7
8. Horse is lamed,	3	4	7	4	18
9. The moral,		9	12	15	36

The S. S. students lost only on topics 7 and 8. These two topics frequently unite. Both horse and man are lamed. The horse lames the man by treading on him and himself by stepping between two stones. The ideas, therefore, combine more readily than any other topics in the king's story. In topic 8 the idea of 'two' is the principal one not occurring before, and we notice its survival in such fusions as 'team of horses,' etc. The notable thing about the P. S. No. 40 records is the great loss of the moral, particularly in P. S. 5B. Frequently we find that the story is concluded by a simple statement that the king now became just, which satisfies the feeling of need for an application of the story to the change in the king's course. This statement is, however, a mere repetition of what is implied in topic 4, the question of the favorite. Hence it is easily omitted. The abstract moral principle is with the younger subjects grasped with difficulty, and, therefore, easily generalized into topics 4 and 3, as the concrete outcome of the story, which they have already chronicled. Similarly topic 3, the account of the change, absorbs topic 2, which describes the condition before the change, and both sometimes disappear in topic 4, where a reason for the change is requested. The details of the king's story, on the other hand, stand apart as concrete entities not easily generalized.

If we examine the record of subtopics, we find that the losses follow the same rule. They occur because the intelligence and experience of the subject did not find them sufficiently striking and distinct to prevent the resolution of similar ideas into each

other. Experience develops memory, not merely by bringing out the relations that are the basis of system, but because it emphasizes the distinctions that without the familiarity that it affords would be quickly lost in generalizations. The literalness and love of concrete in the child does not mean inability to generalize. That power is an inseparable attribute of memory. But it means inability to keep the generalizations from absorbing each other. To him the concrete alone is proof against such destruction.

e. Extent of Loss of Details by Generalizing Processes.

We have already noted¹ that the downright forgetting of an important contributory thought plays a comparatively small part in the condensations of the later reproductions. In the 12 papers in test 2 furnished by E. H. S. 8B students, I have studied the fate of each of the detailed ideas. If we count an idea present when there is an evident substitute present in the reproduction, we shall find the percentage of loss in the first reproduction cut down from 33.4 per cent. to 18 per cent., and the loss between the first and the third reproductions from 19 per cent. to 8 per cent. In the third reproduction 12 out of the 64 ideas of the passage are everywhere represented, 14 are missing only once, and 9 only twice. Only 6 are absent in more than 50 per cent. of the cases. These 6 ideas are expressed in the original passage by the words 'yet,' 'moral,' 'consequent,' 'most,' 'strong,' 'full.' There is quite a little loss in adjectives in the latter part of the passage. An examination of these will convince us that they multiply distinctions with little difference. To one who lacks concrete illustrations of each specific peculiarity, they must give the total impression of a multiplication of words, all of which amounts to eloquence, sarcasm and commanding personal appearance. Instead of a loss of 8 per cent. between the first and third reproductions, we might easily be justified in saying that there is none at all save in unimportant turns of expression, and in adjectives that carry to the students little or no additional meaning. The 47 per cent. of loss from the score of the original passage that we find in the third repro-

¹ P. 68.

duction can, therefore, be accounted for almost entirely by generalization and fusion, about half of which has left clear evidence of its presence in the phaseology of the papers.

f. Summary of the Discussion on the Character of the Changes in the Reproductions.

What are the general results of our four leading investigations on this theme? Our study of underscored words revealed a developing inaccuracy, which we attributed to an irradiation of the feeling of familiarity with the thought over the new words that were used to express it. At the same time, there was a growing loss of confidence, indicated by less underscoring and keeping pace with the greater inaccuracy. As a general explanation of the great loss of words when the ideas remained, and of confidence and accuracy in recognizing them, we suggested the evident reason of the rearrangement of the thought. The effect of this would be to render many of the original words useless, to compel others to be modified in form, and to break up the former order of those that remained so much as to destroy one set of the mechanical associations upon which word memory largely depends. The more rearrangement, the greater the loss of original words, and, because of the loss of recognition through sense of the serial order in the words, the less the confidence of the subject, and the greater his inaccuracy. When the association of the word to the idea had to be relied on to effect recognition, the mere fitness of a word to express a thought would often be sufficient to cause it to be underscored.

We have already discussed¹ the differences between memory for sentences and passages and memory for series of disconnected words. The fusion of the connected thoughts into complex notions of the total meaning of the passages was seen to constitute a 'grip' enormously more effective for holding both ideas and words together than the simple sense of the situation of the learning, which is the only general bond where unconnected words or thoughts are memorized in series. This general sense of meaning preserves many of the details throughout the period during which one is thinking of the passage. Their

¹ See pp. 22-25.

association is thus rendered simultaneous rather than successive. In recall they develop in whatever order the generalizing processes by which they are attacked may dictate. The answers to the questionnaires indicated that, after the subject had assumed an attitude of attention involving suggestions of the situation in which the original passage was learned, the general meaning rose in his mind, and he began to develop the details; easily if they were well memorized and the mechanism of word associations was in effective condition, with more difficulty, and only by reasoning and experimental sentences, if this mechanism failed. From the testimony of the subjects, we are therefore fortified in our notion of the general meaning dominating recall, or better, resolving itself into the details that constitute the recall. From the physiological point of view, we doubtless think such meanings with a large section of the brain, all of which remains in a disturbed condition, while its special elements undergo in serial order intenser excitements corresponding to the wandering of the attention.

From our study of the memory for topics and subtopics as compared with that for details, we discover that with all classes of subjects percentages of loss in the larger themes is at first far less than that in details within the themes that are retained. When the contents of the topic dwindles to a few representative details, then forgetting doubtless ceases to impair these save when it sweeps away all except an inarticulate sense of the larger meaning. But this disappearance of the details while the topics remain is not decay of the living flesh leaving only the skeleton of the thought. Rather it is the resolution of the elements into condensed and generalized forms. It is the body compressed into the germ from which it sprang. Regrouping, with generalization of similar elements, fusion with modification, omission of the unimportant and the easily understood sweep away far more than the omission of the incongruous. The general meaning of the passage that remains, like that which was the product of the details when the passage was first read, is a composite and not an abstraction. It is different from its prototype largely by virtue of the rearrangements that have abolished repetitions.

The feebler the sense of distinctions, whether from the lapse of time, the ability of the subject, or his training, the more ready the mind is to substitute a repetition of some idea already expressed for the thought which is felt to be lacking. We may count on there being some justification, however remote, for such identifying of the distinct. Subtle likenesses, not consciously perceived, are nevertheless felt, and this feeling offers a path of least resistance for the struggling thought. Evident repetitions not in the original appear and form a basis for new regroupings and condensations. To resist such absorption the detail must be characterized by points of difference more potent than the identities with the rest of the passage. Herein appears the effect of training. Its object is quite as much to force to the front differences as to induce generalization. Indeed, since generalization is so easy and distinction so difficult, probably the stress of educational effort must be spent on training acuteness in perceiving the unlike. The difficulty in generalization is invariably due to inability to see the distinctions upon which generalization is based. The stupid mind does not fail to generalize, but generalizes badly. It groups together ideas widely different on the basis of superficial similarities, while the factors that resist such classifications, and, indeed, compel others, remain unheeded.¹

EDUCATIONAL SIGNIFICANCE OF THE RESULTS OF SPECIAL RESEARCH.

It is of some value to the teacher to know that ability to learn correlates to a large extent with ability to remember. Judgments of relative ability based on either of these powers are apt to be valid for both. Marks on daily work will serve to determine the standing that would have been attained in monthly tests, provided the daily mark is based on the amount learned by the student in a given time, and the monthly test is preceded by no special review, in which some labor more assiduously than others. School marks, however, depend very largely on conduct and application. Ability is often only a secondary matter. The small correlation in the case of P. S. No. 40

¹ See Tarde, 'Social Laws.'

pupils between the teacher's marks and rank in the test is evidence of this. The memory test is, indeed, not a satisfactory test of reasoning. But it is probably as near a test of general ability as any could be that appealed largely to specific powers. Doubtless several tests like those submitted by me would, at any rate, determine relative ability in memory. It would certainly be a valuable thing for teachers to know of their classes just what this relative ability is, and, if these tests could be supplemented by others, determining power in the various lines along which school work proceeds, it would be possible for the teacher to tell what part of the results attained in the school is due to industry. If a true judgment of the pupil is desirable, a clear separation of ability from perseverance is equally so.

It is also worth while for the teacher to know that the power to remember connected trains of thought grows with the growth in clear recognition of the factors entering into them. Not age but training is probably the secret of whatever greater ability the older classes possess. Their notion of the separate elements, particularly the abstract ones, is clear enough to prevent the destruction of these units through the generalizing processes that are inherent in the act of remembering. Education aims to strengthen the sense of distinctions quite as much as the consciousness of congruity. It is true that system is the secret of memory. But system rests on the discovery of distinctions unnoted by the unsystematic, which constitute threads of connection between details. It elevates the association between these details from a mere serial association by contiguity to a simultaneous association in which similarity plays a most important part. Now the kind of connection that makes all these details one thought may absorb them so that in recall their separate existence is lost. System is the secret of remembering, but also of forgetting whatever it finds inconsistent or unnecessary.

The meaning into which a group of connected ideas coalesces is often spoken of as a general idea of them. The expression is not inappropriate. It is a composite general idea, a product of the generalization of its details, whether blind or intelligent, systematic or chaotic. Such a composite idea is not so different from an abstraction as we might think. When we

eliminate differences and are left with identities, we have abstractions. But the consciousness of such ideas need not be a barren thing. Indeed, what makes the abstraction worth while is that it comes to us entangled in a mesh of experiences which it serves to systematize. The most valuable of general ideas is, therefore, the concretest of abstractions in the richness of the material which springs into the mind attentive to it. It is in such concrete generalities that education finds its most worthy results.

When we reflect upon the small fraction of what we learned in school that remains within our power of distinct recall, we are prone to think the time spent there to have been largely wasted; at any rate, so far as preparation for the future is concerned. But we must not forget that the impressions that we retain, however vague they may seem, are a product of all the thought involved in their attainment. A statement that to us now might seem fully adequate to indicate the present net result of the subject then studied, would not, if uttered by another, produce in us the idea we actually have. Such an idea really is a product of the experience by which it arose, and it could be given to us by no other agency than that experience. Upon its richness depends the vitality of the idea, its effectiveness in restoring the details out of which it originally sprang.

APPENDIX.

SUMMER SESSION STUDENTS. THE KING WHO BECAME JUST.

Rank.		Ideas.			Words.		
1st Rep.	Age.	1st Rep.	2d Rep.	3d Rep.	1st Rep.	2d Rep.	3d Rep.
1	Adult.	67 +	64	56	114 +	89 +	72
2	"	64	52	55 +	97	60	65 +
3	"	62	55 +	56 +	95 +	73 +	77 +
4	"	58 +	57 +	56	98 +	89 +	90
5	"	58	51 +	49 +	85 +	63 +	49 +
6	"	57	53 +	47	72 +	59	49 +
7	"	56	49 +	49	78 +	57	55
8	"	54	49 +	50 +	71	60	52
9	"	51 +	46 +	40 +	82 +	60	43
10	"	51	47	45 +	68 +	54	54
11	"	51	47	42	76	58	41
12	"	49	49 +	48 +	72 +	69 +	63
13	"	49	37	35	64 +	37	31 +
14	"	45	46 +	39	71 +	64	50
15	"	45	37	35 +	50	27 +	26
16	"	42	41 +	38 +	48 +	43	34
17	"	41	36 +	35 +	58	39	33

P. S. 7B PUPILS. THE KING WHO BECAME JUST.

Rank.		Ideas.			Words.		
1st Rep.	Age.	1st Rep.	2d Rep.	3d Rep.	1st Rep.	2d Rep.	3d Rep.
1	14	63 +	55	57 +	108	70	85
2	16	63	63	63	105 +	105	105
3	13	61	61 +	60	100	98	99
4	15	59	51	51 +	93 +	79 +	78 +
5	15	57 +	55	52 +	77	69	58
6	13	57 +	54 +	48	80	73 +	62 +
7	13	57	56 +	58	82 +	84 +	76
8	12	57	53 +	53 +	89 +	76 +	73
9	14	56	56	41	91 +	77 +	47 +
10	16	56	53 +	46	82 +	73 +	54 +
11	14	55 +	49 +	44	80 +	66 +	50 +
12	15	54 +	52 +	48	76 +	67	58
13	13	53	56 +	50	63	67 +	65
14	15	53	53 +	40	69 +	64	34
15	12	52 +	45 +	42 +	64	50	44
16	15	52	44 +	39	75 +	60 +	42 +
17	14	50	46 +	47 +	76	71	63
18	14	49 +	53	52	68 +	64	60

Rank.			Ideas.			Words.	
1st Rep.	Age.	1st Rep.	2d Rep.	3d Rep.	1st Rep.	2d Rep.	3d Rep.
19	13	48+	49+	57+	70	68	40+
20	15	48+	42	38+	59	50+	42+
21	14	46+	47	36+	64	59	37
22	13	45	40+	30+	64+	52	40
23	14	45	39+	23+	57	45+	25+
24	14	45	37	33	66+	44	41
25	13	44+	41	34	64+	59+	41
26	12	43+	41+	39	62+	52+	50+
27	13	42+	43+	40+	62+	58+	47+
28	—	42	40+	30	52	50+	32
29	12	41	30+	26+	47	35	26+
30	14	38+	38+	36+	48+	39+	41
31	14	36	32+	22	47+	32	21+
32	13	35+	31+	26+	44+	36+	29+
33	15	26	19+	15	30+	17	12

P. S. 6B PUPILS. THE KING WHO BECAME JUST.

Rank.			Ideas.			Words.	
1st Rep.	Age.	1st Rep.	2d Rep.	3d Rep.	1st Rep.	2d Rep.	3d Rep.
1	11	61	61	61	82	87+	85
2	15	59	58+	56	99+	95	89
3	12	58+	60	53+	101	100	81+
4	12	58+	51+	53	71+	53	54+
5	12	56+	58+	54	89	92	78+
6	14	56+	58+	53	86	84+	76+
7	12	54	53+	49	83	69+	56
8	14	54	50+	54	78+	68	72+
9	15	52+	55+	55+	80	89+	90+
10	11	52+	50+	48+	69+	68	60
11	14	51	+55	49	73+	69+	50
12	11	51+	54	50	68+	73+	66
13	13	51+	51+	51	71	70+	64+
14	13	51+	45	41	67+	51+	42
15	12	51	48+	43	67	61+	48
16	13	50+	44	38	77+	55+	37
17	14	49+	43	42+	67+	54	48
18	12	49	49	41	60+	62+	54
19	—	49	47+	49	66+	57	58+
20	14	48+	50+	45	68	65+	57+
21	13	48	49	47	68	65	59
22	12	47+	49	41	68	70+	51
23	14	47+	48+	46	62	61+	57+
24	14	47+	48+	41	70+	75+	55+
25	11	46+	45	43	62+	62+	60+
26	11	46	49	37+	51	57	45
27	15	46	44+	41	66	53+	53
28	13	45+	48	47	52+	60+	54+
29	13	43+	42+	32+	50+	51	32

Rank.			Ideas.			Words.	
1st Rep.	Age.	1st Rep.	2d Rep.	3d Rep.	1st Rep.	2d Rep.	3d Rep.
30	14	43	33+	35	55	41+	38+
31	14	42+	37+	19+	56+	49+	20
32	11	42	35+	29+	52	48	30
33	12	42	33	32+	54	36+	37+
34	13	40+	35	29+	53+	45	32
35	12	40	39+	44+	62	61+	61
36	12	39+	42+	38	50	53+	51
37	13	39	38+	34	52	41+	29
38	11	37+	36+	35+	43	39	35
39	14	35+	33+	29+	52	41	46+
40	13	32	25+	24	46+	33+	29+
41	12	25	27+	27+	38	43+	41+
42	12	22+	21+	22	35	31+	31+
43	14	11+	10+	15	21	17	22+

P. S. 5B PUPILS. THE KING WHO BECAME JUST.

Rank.			Ideas.			Words.	
1st Rep.	Age.	1st Rep.	2d Rep.	3d Rep.	1st Rep.	2d Rep.	3d Rep.
1	10	57	62	59	91	97	96
2	13	53	49+	42+	77	55+	51+
3	14	52	49+	41	73+	67+	52
4	12	51	42+	37	71+	53+	52+
5	13	49	47	34	75+	63+	33+
6	13	47	48+	35+	58	45+	43
7	11	47	45	43	65	68	59+
8	12	43+	43+	42+	52	50+	51
9	14	42	41+	39	37	36+	31+
10	10	42	41+	36+	56+	56	50+
11	10	42	40	39	64	51+	44+
12	13	42	39	28	63+	53+	43+
13	12	42	37+	36	59	53	48
14	11	42	31+	32	69+	52	48+
15	10	38	34+	27+	51	40+	29+
16	13	38	30	20+	54+	32+	19+
17	12	37	33+	28+	53	53	38
18	12	32	31+	26	44+	45+	38
19	11	32	29+	33	40+	34+	43+
20	13	31	34	29+	27+	29+	24+
21	—	31	30	24	44	41+	38
22	12	31	27+	26+	43	41	34
23	13	29+	28	27	34	32+	30+
24	13	27	24	19	41	31	23+
25	10	23	26+	24	38	44	35+
26	12	22	13	14+	27+	13+	14+
27	10	21	21+	20	30	28	25+

E. H. S. 8B STUDENTS. CICERO.

Rank.	Ideas.			Words.		
1st Rep.	1st Rep.	2d Rep.	3d Rep.	1st Rep.	2d Rep.	3d Rep.
1	62		62+	118+		117
2	48+	46+	41	84+	80	67
3	47	47+	46+	84+	81	80+
4	44	43	35	74+	64+	52
5	42	42	36	77	62	53
6	41+	31	30	62	48	40+
7	40+	48+	23	73	89	46
8	39+	23	17	78	43+	33
9	37	35+	31+	73	69	52+
10	37	30	22	64+	45+	31
11	36+	36+	32	66+	66+	55+
12	36	34+	26	61	61+	41

E. H. S. 4B STUDENTS. CICERO.

Rank.	Ideas.			Words.		
1st Rep.	1st Rep.	2d Rep.	3d Rep.	1st Rep.	2d Rep.	3d Rep.
1	57	55	48	104	103	77
2	53+	57+	37+	103+	100	56
3	47	45	38+	90+	85	73+
4	45	47+	44+	82+	94+	82+
5	45	41	28+	81	68+	43+
6	43	41	21+	69+	57	32
7	42	40+	33+	74+	60	46
8	40	34+	32	72+	57	44+
9	37	25+	26	64+	46+	49
10	36	30	9+	62	54	14+
11	34	24	12+	57	41+	20+
12	33	34+	30	55+	57	47
13	32+	28+	18+	51	42	28
14	30+	24+	14+	47	42+	20+
15	30+	28+	8	47+	34+	9+
16	27	24+	11	39	37+	13
17	26+	18+	15+	42+	22+	23
18	24+	25+	17	49+	39+	23+

E. H. S. 1A STUDENTS. CICERO.

Rank.	Ideas.			Words.		
1st Rep.	1st Rep.	2d Rep.	3d Rep.	1st Rep.	2d Rep.	3d Rep.
1	60	30	14	102+	52	18
2	56+	50+	33	103	84+	43+
3	48+	48+	44	84	79	67+
4	47	43+	37+	75+	69+	55
5	45+	44+	35	82	70+	49
6	44	38	26+	76	61	37
7	41+	32+	25+	73	47+	29
8	39	38+	29	57	47	32+

Rank.	Ideas.			Words.		
1st Rep.	1st Rep.	2d Rep.	3d Rep.	1st Rep.	2d Rep.	3d Rep.
9	38	35	35+	73+	67+	63
10	38	28+	25+	67+	44+	24
11	38	32	22	68+	57	38+
12	36+	26+	11	56	33	13+
13	36	36+	28	51	50	46+
14	34+	28+	24	46+	36+	29+
15	30+	30+	27+	48	43+	40+
16	30	15+	7	57+	26	15
17	29+	25	14+	49+	37+	23
18	29+	22+	11+	48+	33+	16
19	29	23+	19+	54+	38	27
20	28+	29	17+	38	42+	25
21	24+	21+	11+	40	29	15+
22	23+	13	13+	34	22	22
23	19	21+	12+	29+	29	15+

COLLEGE STUDENTS. CICERO.

Rank.	Ideas.			Words.		
1st Rep.	1st Rep.	2d Rep.	3d Rep.	1st Rep.	2d Rep.	3d Rep.
1	61		36+	111		41
2	60	56	54	102	92	78+
3	59	55	54	113	92	85
4	58		47+	104		65
5	58	35+	33+	106+	38+	43+
6	57	45	43+	97	65	62
7	56+	49+	47	103	88	75
8	54+	41+	32+	102	55+	35+
9	53		55+	93		97
10	49	41	41+	93+	65	64+
11	48	35	29+	74	39	23
12	46+	39+	37	71+	52+	40
13	45	37+	37+	67	46+	39
14	45	33+	32	70	41	31+
15	42+	30+	26	69	40+	27
16	40	22+	10	64	24+	6
17	38	35	29	68+	38	29+
18	37	24	21	67	29	17+
19	34+	20+	9+	50	15+	11
20	34	26	24+	49+	34	31
21	30	30	24	45+	39	26

COLLEGE STUDENTS. THE HISTORY OF THE JEWS.

Rank.	Rank.	Ideas.			Words.		
1st Rep.	Test 2.	1st Rep.	2d Rep.	3d Rep.	1st Rep.	2d Rep.	3d Rep.
1	10	52+	42+	43+	53+	32	30+
2	7	51	41+	43+	61	42	44
3	13	43	31+	32	53	39+	37+
4	6	41	27+	25	48	30	22

Rank. 1st Rep.	Rank. Test 2.	Rank. 1st Rep.	Ideas. 2d Rep.	Rank. 3d Rep.	Rank. 1st Rep.	Rank. 2d Rep.	Rank. 3d Rep.
5	14	39	21+	21	50+	21+	20+
6	19	38	17	13	27	15	5
7	5	36	24	29+	59	32+	34
8	8	35	34	31+	49	49+	43+
9	20	35	27	21+	43	35+	21+
10	15	35	25	26+	36+	25	17+
11	3	35	23	21	34	8	12
12	18	35	23	11+	39	24+	7+
13	12	35	22+	19+	37+	14+	13
14	17	33	28	23	36+	35	22
15	9	32		25+	37		33
16	11	32	26+	25+	35	19	20+
17	16	32	27+	4	46+	26+	2
18	21	28	17	17	33	12+	15+

GRADUATE STUDENTS. THE HISTORY OF THE JEWS.

Rank. 1st Rep.	Rank. 1st Rep.	Ideas. 2d Rep.	Rank. 3d Rep.	Rank. 1st Rep.	Rank. 2d Rep.	Rank. 3d Rep.
1	67	48+	48+	115	64+	53+
2	60	57+	54+	100	85	81+
3	57+	40+	45	68	45	47+
4	55	43+	37	66	46	32
5	51+	42	32+	58	44	33
6	46+	51+	40+	72	69+	49+
7	46+	45+	40	63	50+	44+
8	46	33+	32	54	28	27
9	44	40+	27	40	37+	22
10	40	18+	19+	53	23	15+
11	39+	29+	18	44+	29	20+
12	38	32	31+	59	38	33
13	38	35	25+	48	33	26+
14	34	32	27	35+	27+	23
15	32	22+	28+	36	17+	21+
16	26+	22+	20	40+	13+	17
17	25+	18+	5+	38	23+	6
18	16	10+	7	27	6	4

GRADUATE STUDENTS. THE DUTCH HOMESTEAD.

Rank. 1st Rep.	Rank. Test 3.	Rank. 1st Rep.	Ideas. 2d Rep.	Rank. 3d Rep.	Rank. 1st Rep.	Rank. 2d Rep.	Rank. 3d Rep.
1	1	77	50	37+	111+	60+	40
2	2	73	50	41+	131	91	60
3	12	70	59+	50	96+	70	59
4	6	64	62	56+	112	104+	84+
5	8	62	49	40	98	79	53
6	5	61	45	45+	102+	62	55
7	13	60	57+	55+	98+	81+	78
8	11	60	54+	47+	90	73	53

Rank 1st Rep.	Rank. Test 3.	1st Rep.	Ideas. 2d Rep.	1st Rep.	2d Rep.	Words. 2d Rep.	3d Rep.
9	16	57	35	26+	80	39	27
10	7	53	53+	47+	81+	71	54+
11	15	53	46	41	77	62+	47+
12	10	49+	37	35+	79+	52	45+
13	4	47+	41	31	77	60	39
14	14	44	40+	29	78+	70	47+
15	17	32	23	25+	51	28	35

GRADUATE STUDENTS. THE STAGES IN THE DEVELOPMENT OF HUMAN THEORIES.

Rank. 1st Rep.	Rank. Test 3.	1st Rep.	Ideas. 2d Rep.	3d Rep.	1st Rep.	Words. 2d Rep.	3d Rep.
1	2	73	34	49+	128	42	79
2	5	72+	59+	40	101	79+	37+
3	9	68+	41+	12+	90	52+	16
4	1	53+	20+	29	78	18	23
5	4	52	25+	25+	64+	29	17+
6	11	49	34	19+	56+	31	13+
7	6	42+	45	17	70	71	19
8	12	40+	31+	25+	54	37	25+
9	15	35	24+	19	40+	26	20
10	13	35	20+	13+	43	36+	20
11	8	34+	17+	5	42	24	3
12	16	31+	23	9	34+	31	14
13	14	28+	26+	16+	47	35+	21
14	18	27	22+	24+	43	32	34



VITA.

The writer was born in LaSalle County, Illinois, December 17, 1869; removed to California in 1880; graduated from University of California, 1890, degree Ph.B.; teacher in Secondary School, San Mateo, Cal., 1890-92; Fellow in Philosophy, University of California; 1892-95; took degrees A.B. 1893, A.M. 1894, University of California; principal and teacher of classics, Woodland High School, Woodland, Cal., 1895-97; Instructor in Psychology and Education, California State Normal School, Chico, Cal., 1897-1901; Fellow in Education, Teachers College, Columbia University, 1901-1902; Professor of Education, Adelphi College, Brooklyn, N. Y., 1902-.

